SCHOOL SCIENCE

Vol. 6 No. 1

March 1968

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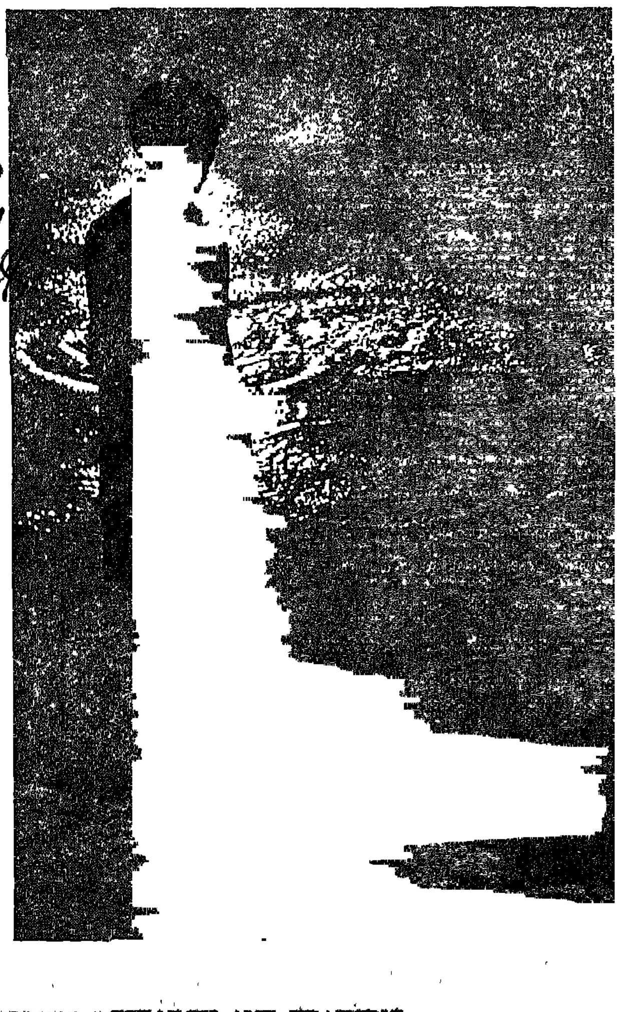

A Study of the Phenomenon of Reflection and Refraction

NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

SCHOOL SCIENCE QUARTERLY

Vol. 6 No. 1

MARCH 1968

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Annual
Rs. 8.00

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Articles covering these aims and objectives are invited.

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Illustrations may be limited to the minimum considered necessary, and should be made with pen and indelible Indian ink. Photographs should be on glossy paper, at least of post-card size, and should be sent properly packed so as to avoid damage in transit.

Published at the Publication Unit, B 31, Maharani Bagh, New Delhi 14 by P.N. Natu, Secretary, National Council of Educational Research and Training and printed at the Indraprastha Press (CBT), Nehru House, New Delhi 1

SCHOOL SCIENCE QUARTERLY

Vol. 6 No. 2

JUNE 1968

CONTENTS

Annual
Rs. 8.00

Per copy
Rs. 2.00

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SCHOOL SCIENCE QUARTERLY

Vol. 6 Nos. 3 & 4

September/December 1968

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Cover Photograph Courtesy : U.S I.S.

Annual Rs. 8.00

Price Rs. 4/-

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The Amelioration of Wheat

B. P. Pal

WHEAT is one of the earliest plants cultivated by man and it has been said that the story of wheat is the story of our civilization. For some hundreds of thousands of years, primitive man was a hunter who knew nothing of either cultivated plants or domesticated animals. The cultivation of plants like wheat and the domestication of milch and meat animals greatly diminished the danger of starvation and enabled primitive man to give up his nomadic habits and to live in villages. The grouping of families together in settled communities led to the development of an increasingly complex social existence, consciousness and creative genius.

If it were possible to trace the development of agriculture back to its starting point, it would be found that all our cultivated plants and modern livestock animals existed then in the wild state. The cultivated wheats and their wild relatives have been studied very intensively, and from these studies a clear picture is now beginning to emerge of the evolution of modern wheat. Wheat is seperated into distinct groups which differ from one another in many ways and are, therefore, classified as separate species under the genus *Triticum* Authorities differ on the number of distinct species of wheat but it has been established that all the wheat species, whatever their number, fall into three distinct groups on the basis of their chromosome numbers. The chromosome numbers of the three groups, discovered independently by Sakamura and Sax in 1918, are 14, 28 and 42 respectively. It is interesting to note that Schulz a German botanist, had arranged the wheats into these three groups on the basis of their morphological characteristics in 1913, well before their chromosome members became known. Some characteristics of the currently recognized wheat species as well as their distribution and antiquity are given in the Table on page 2

Descent of Modern Wheat

The 28- and 42-chromosome wheats, termed tetraploids and hexaploids respectively, have all arisen from 14-chromosome (i.e., diploid) wheat and related grasses through hybridization followed by chromosome doubling.

TABLE

(Based on Mangelsdorf, 1953)

Scientific Name	Common Name	Chromosome Number	Occurrence	Grains	Geographical Distribution	Earliest Evidence
T. boeticum	Wild einkorn	14	Wild	Hulled	Western Iran, Asia Minor, Greece, Southern Yugoslavia	Pre-agricultural
T. monococcum	Einkorn	14	Cultivated	Hulled	Eastern Caucasus, Asia Minor, Greece, Central Europe	4750 B C.
T. dieoccoides	Wild emmer	28	Wild	Hulled	Western Iran, Syria, Northern Palestine, North-eastern Turkey, Armenia	Pre-agricultural
T. Dicoccum	Emmer	28	Cultivated	Hulled	India, Central Asia, Northern Iran, Georgia. Armenia, Europe, Mediterranean area, Abyssinia.	4000 B.C.
T. timopheevi		28	Cultivated	Hulled	Western Georgia, Azerbaijan, Armenia	Twentieth century
T. durum	Macaroni wheat	28	Cultivated	Naked	India, Central Asia, Iran, Mesopotamia, Turkey, Abyssinia, South-eastern Europe, U S.A.	100 B.C.
T. carthlicum	Persian wheat	28	Cultivated	Naked	Georgia, Armenia, North-eastern Turkey, Iran	No prehistoric remains
T. turgidum	Rivet wheat	28	Cultivated	Naked	Abyssinia, Southern Europe	No prehistoric remains
T. polonicum	Polish wheat	28	Cultivated	Naked	Abyssinia, Mediterranean area	Seventeenth century
T. vulgare	Common wheat	42	Cultivated	Naked	World-wide	Neolithic period
T. sphaerococcum	Shot wheat	42	Cultivated	Naked	North-western India	2500 B.C.
T compactum	Club wheat	42	Cultivated	Naked	South-western Asia, South-eastern Europe, U.S A.	Neolithic period
T. spelta	Spelt	42	Cultivated	Hulled	Central Europe	Bronze Age
T macha		42	Cultivated	Hulled	Western Georgia, Azerbaijan, Armenia	Twentieth century
T. vavilovi		42	Cultivated	Hulled	Transcaucasia (Georgia, Azerbaijan, Armenia)	Twentieth century
T. zhukovskyi		42	Cultivated	Hulled	Transcaucasia (Georgia, Azerbaijan, Armenia)	Twentieth century

First Stage

The diploid wheats, which form the lowest step of the evolutionary staircase leading to the development of modern bread wheat, consist of two species: *T boeicum* and *T. monococcum*, known as wild einkorn and einkorn respectively. Their spikes contain a single seed per spikelet and hence their name. Carbonized grains of both these species were found at the 6,700-year-old site of Jarmo in Eastern Iraq, the oldest village yet discovered, but whether they are the only wheats occurring in this ancient village site cannot be said with certainty. Both the diploid wheats have fragile rachis and tightly hulled seeds Furthermore, both the species have the same set of chromosomes, *i.e.*, genome A, and can be inter-crossed with ease, yielding highly fertile offsprings. Except for slight differences regarding seed size and the degree of rachis fragility, the two species are essentially similar and undoubtedly the einkorn is the cultivated counterpart of the wild form.

Wild einkorn occurs in the Armenia and Georgia regions of the Soviet Union, and in Turkey, Eastern Caucasus and Western Iran. It is found as a common grass in the hilly tracts of Greece and Bulgaria and as a weed in vineyards of southern Yugoslavia. Cultivated einkorn is believed to have originated in the mountains of north-eastern Turkey and south-western Caucasus, or possibly slightly farther south in eastern Iraq. Carbonized monococcum grains found in neolithic deposits of the lake-dwellers of Switzerland and in many other sites in central and north-eastern Europe and the impressions of einkorn ears identified in neolithic pottery in Britain and Ireland indicate that certainly it is an ancient cereal. But how old its cultivation is, cannot be said with surety, since information on the remote past comes chiefly from excavations which, besides being few, have rarely provided conclusive evidence. Apparently, little significant change has occurred in this progenitor species over the centuries, although it is still grown in spite of its low yields in some parts of Greece, Crimea (USSR), Spain and Morocco, usually in hilly regions with thin soils.

Second Stage

In the next stage of evolution are the tetraploid species which arose from the hybridization followed by chromosome doubling between a diploid wheat and a 14-chromosome-related wild grass, identified by Sarkar and Stebbins (1956), and later upheld by Riley, Unrau and Chapman (1958), to be *Aegilops speltoides* var. *liugstica* or a closely related form. Only one of the tetraploid species—*T. Dicoccum,* also called wild emmer—is found growing wild in Southern Armenia, north-eastern Turkey, Western Iran, Syria and Northern Palestine. Closely related to wild emmer is its cultivated version called emmer, and both of them have fragile rachis and tough glumes. Well-preserved spikelets, scarcely different from those of the modern emmer, have been found in Egyptian tombs of the Fifth Dynasty while remains or impressions of this wheat have been commonly found in neolithic sites in continental Europe, Britain and Ireland. These evidences show that emmer may well have been

the chief cereal of the Near East, from pre-historic times to the Graeco-Roman periods.

The tetraploid wheats were the first to produce species with tough rachis and free-threshing grains. Although four such species are known—*durum*, *turgidum*, *carthlicum* and *polonicum*—yet none of these wheats except *durum* is of great commercial importance today. Recent genetic analysis has shown that these species, which inter-cross freely giving fertile hybrids, are differentiated from each other mostly with respect to single loci and, hence, may be considered sub-species of one basic species. The oldest of these, *durum*, is believed to have been cultivated during the Greeco-Roman period about the first century B.C. This species, which is the best wheat for the manufacture of macaroni, spaghetti and other edible paste products, is still grown fairly extensively in Italy, Spain and parts of the USA, and also in our country. *T. Turgidum*, called the rivet wheat, deserves mention since it is the tallest growing and, under favourable conditions, one of the most productive wheats. However, its grains are soft, yielding a weak flour unsuitable for bread-making.

Another tetraploid species—*T. Timopheevi*, discovered in this century by Russian botanists and known only in Western Georgia—appears to be quite differentiated from the rest of the species of this group. This species is resistant to virtually all diseases that attack other cultivated wheats, including rusts, smuts and mildews and is obviously of great practical interest to plant breeders. Inter-specific crosses involving *T. Timopheevi* have led to the development of cytoplasmic male sterile lines in bread wheat, offering scope for the commercial exploitation of hybrid vigour in wheat production.

Third Stage

The hexaploid group consists of seven species which are all cultivated; none has ever been found growing wild. Of these, *T. Spelta*, *T. Macha*, *T. Pavlovi* and *T. Zhukovskyi* are, like einkorn and emmer, hard threshing species while *T. Bulgare*, *T. Sphaerococcum* and *T. Compactum* are free-threshing and, popularly known as bread wheats, account for about 90 per cent of all the wheat grown in the world today. The hexaploid species, like the tetraploids, are differentiated from each other with respect to only one or a few loci and have been regarded by Mackey (1954) and also by Sears (1959) to be sub-species of a basic species designated *T. Aestivum*.

All the hexaploid wheats are products of hybridization followed by chromosome doubling between tetraploid wheats containing the A and B genomes with a wild 14-chromosome grass, *Aegilops squarrosa*, containing the genome D. The species, *T. Zhukovkyi*, seems to be an exception having the genome constitution AAAABB instead of AABBDD, as reported by Swaminathan. Some of these hexaploid species have already been artificially synthesized by various research workers, thus supporting the above conclusions. The particular value of the bread wheats lies not only in their greater yield potential and in their free-threshing naked grains but also in the peculiar quality of their gluten, the protein component of wheat grain. Of all the cultivated cereals, only the bread wheats are capable of producing the light, fluffy, leavened

breads we know today. The D genome seems to have contributed not only to the bread-making quality but also tolerance to cooler growing-seasons, extending the adaptability of the wheat plant from the equator to the Arctic circle.

Which one of the hexaploid species arose first, or where, and when the modern bread wheat first occurred are still matters for intelligent conjecture. Grains of *sphoerococcum*, a species considered to be endemic in this country, have been found at the most ancient site in India—Mohenjo-Daro, dated about 2500 B.C. The wheat found in neolithic store-chambers in Hungary has been identified as *T. Compactum*. All the archaeological evidence, none in itself conclusive, indicates that the bread wheats originated much before the time of Christ but later than einkorn or emmer. The studies conducted by Swaminathan and his associates have indicated that the hexaploids—*vulgare, spelta, macha* and *zhukovskyi*—are likely to have had independent origins from pre-existing tetraploids All hypotheses making them interdependent in evolution raise more questions than they solve. Which one of these hexaploids arose first has to be largely decided by archaeological and historical evidence and not from cytogenetic analysis alone.

Early Improvement of Wheat

Before knowledge of sex and inheritance mechanisms in plants was gained, the only method practised by farmers themselves or by professional breeders was selection which was carried out unceremoniously with the aid of a trained eye and an impulsive hunch. This practice was based on the belief that by picking a fine plant, then picking the finest of its progeny and repeating the process year by year, an improved form would gradually be built up. There is no better example of the value of selection as a means of improving wheat than that provided by Hallett's work in England. Starting in 1857 with an ear of wheat 4⅜ inches in length and containing 47 grains, by 1861 Hallett had produced one 8¾ inches long with 123 grains. With slight modifications this method was followed by early distinguished breeders like Le Couteur, Patrick Shirreff, Vilmorins, Nilsson and Hays who bred many successful varieties of their times such as 'Improved Fife'. This method was put on a sound scientific basis by the concept of genotype and the pure-line theory developed by Johannsen (1903). The usual procedure in pure-line breeding has been to select a large number of single plants, compare their progeny in field trials, and save the single most valuable progeny as a new variety. It is obvious that the most that selection can accomplish is the isolation of a pure form from a mixture of forms. Mass selection differs from pure-line selection in that a number of plants, rather than just one, are selected to make up the new variety. In other words, varieties developed by this method include fewer genotypes than parent population but more than 'single' genotype of varieties developed by pure-line selection. It should be noted that one outstanding merit of the wheat plant, lending it so well to improvement by the selection method, was its self-pollination system. Once the mechanism of sex in plants became known, emphasis was shifted to the value of crosses as a

means of obtaining new combinations of characters. William Farrer of Australia, during the latter part of the nineteenth century, approached present-day plant-breeding methods and developed many wheat varieties of great value. He selected parents for crosses on the basis of their characters, strongly featuring the value of composite crosses as a means of inducing maximum variation. Thus, 'federation,' a variety of wheat that was early-maturing and non-shattering, with stiff, erect, short straw, was produced by him as the result of a definite attempt to obtain a variety of wheat suited to 'combine' harvesting. As an illustration of this principle, and parentage of 'federation' is given below:

Improved Fife × Etawah
↓
Yandilla × Purple Straw
↓
Federation

Another shining example of this era is the development of the famous variety, 'marquis', in Canada, by Saunders.

The rediscovery of Mendel's laws of inheritance by De Vries, Correns and Von Tschermak, in 1900, stimulated the extensive studies of the laws of heredity that have led to the present system of breeding crop plants with a definite plan to obtain a desired combination of characters. With the addition of the concept of dominance and, linkage, the whole process of segregation turned out to be so definite and orderly that the breeder could confidently forecast not only what types would occur in the F_2 generation of cross, but also the proportions in which they would be found. As these facts became evident and it was realized that plant-breeding was no longer, to quote Lindley's apt description, "a game of chance played between man and plants", almost every wheat-growing country founded experimental stations for solving its own problems of wheat improvement.

A new dimension to wheat-breeding was added by Sir Rowland Biffen who demonstrated for the first time that like other characteristics of the wheat plant, resistance to rusts also followed the Mendelian laws. He announced at the beginning of this century that 'plant-breeding offers no more fascinating problem than that of attempting to control epidemics of fungal diseases by developing resistant varieties.' Thus, breeding for disease resistance was also included in the list of objectives of wheat-breeders.

With the increase in our theoretical understanding of the breeding principles, techniques were refined and their application extended. Thus, the back-cross method was developed to improve the existing successful varieties with respect to one or two specific defects. The concept of a broad genetic base in breeding programmes replaced the early idea of pure-line breeding. When it became known that the success of a breeding programme depends upon the genetic variability present in the parent populations, efforts were directed towards collecting all available genetic stocks so as to preserve the valuable germ plasm for future use. After the important discovery by Muller in 1927 that the rate of spontaneous mutations could be greatly accelerated by means of X-rays, mutation-breeding was taken up with calculated advantage to induce genetic variablity and thus to make

selection more effective. The 'translocation technique', developed by Sears (1956) to transfer the leaf-rust resistance from *Aegilops umbellulata* into bread wheat, has proved very useful in interspecific and integeneric transfer of desirable genes. Mutation-breeding has thus become a potential aid to conventional wheat-breeding. I may quote here John Percival, one of the greatest wheat experts of his time, who wrote in 1921 that "it is important to emphasize the fact that the creation of plant characters is beyond human power, and the causes which lead to the production of hereditary variation are quite unknown". How soon has human power transgressed its boundaries!

The Indian Scene

Wheat has been under cultivation in India since very ancient times and, in fact, at least one of its forms is considered to have originated, in the remote past, in the region of North India and Afghanistan. Identification of carbonized wheat grains found at the Mohenjo-Daro site as *T. Sphaerococcum* indicates that bread wheat was under cultivation in the Indus Valley 5,000 years ago. The wheat crop still occupies an area of approximately 32 million acres, yielding about 10 million tons of grains Wheat cultivation in India is confined mainly to the *vulgare* and *durum* species, others being grown in small pockets. By far the greater area is under the *vulgare* wheats, particularly in the very extensive wheat-growing regions of Northern India. The *durum* wheats are grown mainly in some parts of Maharashtra and Madhya Pradesh. The dicoccum wheats are grown in very small areas of Maharashtra, Madras, Andhra Pradesh and Mysore. A special feature of Indian wheat is the relatively short season in which it grows. While, in some Western countries, the crop stands in the field for nine or ten months, in India it is ready for harvest in four to six months after sowing.

Early Work

It may sound strange today to know that there used to be an export market for Indian wheat in the early days. Then, the Indian wheat used to be a mixture of the soft, white sorts, and was being valued at a rather low price because it was not up to the standard required, particularly in regard to milling and baking qualities. The British Government, then, considered the desirability of improving the Indian wheat by suitable methods of breeding as was done then in England and other countries. Accordingly, investigations on wheat were started by Albert Howard and Mrs. Howard with the help of A. R. Khan, of the Imperial Institute of Agricultural Research at Pusa in Bihar. This work started during the first decade of this century, showed in its early stages that the Indian wheat material was very rich in valuable characters. The first stage of improvement of the crop consisted of survey and collection of indigenous wheats and their separation into pure types. The earlier selections made from these collections were very outstanding, especially Pusa 4 and Pusa 12 (now N.P. 4 and N.P. 12). They compared well with the best quality wheats in the world and N.P. 4 was distinguished enough to get the first prize four times, between 1916

and 1920, in international grain exhibitions.

Improvement of the wheat crop by means of selection from the local material was also carried out in different wheat-growing states of the country. In Uttar Pradesh, the variety Kanpur 13 was evolved by Leake in collaboration with the Howards. Wheat improvement in the Punjab by Milne led to popular varieties like types 11, 8-A and 9-D. The work initiated by Sir Geoffrey Evans in Madhya Pradesh resulted in the isolation of a number of improved strains like A.O. 13, A.O. 88 and A.O. 90. The improved varieties bred in the Bombay State included the *durum* types: 'Motia' and 'Gulab'.

Varieties Developed by Hybridization

Any given variety possesses only a few desirable characters and thus the limit of improvement by means of selection is reached when the best of the existing varieties have been picked out. The plant-breeder obviously cannot rest content with this. By means of hybridization, he tries to incorporate in one variety more and more desirable characters brought in from different varieties. Hybridization has been the most successful methods for developing better varieties of crop plants. In the beginning, our main object in hybridization programmes was to produce wheats with high protein content, attractive grains and good yielding ability. This line of work continued up to the middle thirties during which period a number of improved wheat varieties like N.P. 52, N.P. 80-5, N.P. 114, N.P. 120, N.P. 125 and N.P. 165 were bred at the Indian Agricultural Research Institute. Similar work was also taken up at the same time in the different wheat-growing states of the country, and it resulted in the evolution of varieties like C. 518 and C. 591 in the Punjab, A.O. 68 and A. 115 in Madhya Pradesh, and Jaya, Vijay and Niphad 4 in Bombay.

In 1934, a committee of experts met at Simla to discuss ways and means of fighting the ravages of rust, and the emphasis in wheat improvement shifted to breeding for disease resistance. I had the privilege of being the leader of the wheat breeding team and worked in close cooperation with the plant pathologists. In Northern India all the three rusts are responsible for the damage to the wheat crop and hence the wheat varieties which are evolved should be resistant to all these three rusts. In view of the complexity of the problem, the work was taken up in two stages, the first being the production of varieties separately resistant to stem, leaf and stripe rusts, and the second the combining of resistance to all the three rusts. Satisfactory progress was made at the Indian Agricultural Research Institute with regard to the first stage which involved hybridization with resistant foreign varieties. Thus, N.P. 783 and N.P. 784 were highly resistant to brown rust; N.P. 785 and N.P. 786 to yellow rust; and N.P. 789, N.P. 790, N.P. 798 and N.P. 799 to black rust. The second phase of the work was also begun for building up resistance to all the three rusts. A few strains have already been produced that combine a useful degree of resistance to all the three rusts with very good agronomic characters. One of these, N.P. 809, is doing very well in the hilly areas of Himachal Pradesh.

Systematic breeding for rust resistance in Peninsular India was also started in Bombay and Madhya Pradesh where only stem rust prevails. This programme yielded successful varieties like the 'Kenphad' strains and 'Hybrid 65'. Work on breeding for rust resistance was likewise taken up in certain other states, including the Punjab where varieties resistant to one or more rusts are reported to have been evolved. Among these, mention may be made of C. 217, reported to be good for *barani* conditions in the Punjab, and C. 281 with high yield and good grains suited for cultivation in the Haryana tract.

Although the discussion so far has been confined to the rust disease, it may be mentioned that the loose smut disease which is only second in importance to the former has received its due share of attention. A number of wheat varieties evolved at the Indian Agricultural Research Institute by me, and conveniently referred to as the wheats of the 'New Pusa 700 series,' are notable for their high degree of tolerance to the rusts combined with very high resistance to the loose smut disease.

Considerable work has also been done on the nutritive value of the improved varieties. Besides the chapati-making quality, the baking or loaf-making quality of Indian wheats is also receiving our attention.

Realizing that breeding for special conditions is of particular significance for the future cultivation of wheat in India, efforts were directed at evolving two categories of varieties: those suitable for intensive cultivation and those suited to rainfed conditions. The establishment of several river valley projects and new irrigation systems and the growing use of fertilizers by our farmers necessitate the development of varieties suited for intensive agricultural practices. A non-lodging habit and the ability to utilize the applied fertilizer for giving economic returns will have to be essential qualities of the varieties evolved in the future. Already several new Pusa wheats (N.P. 823, N.P. 824, N.P. 871 and N.P. 876) possessing these attributes have been bred and distributed among farmers. Several states are also working along these lines and a variety, C. 306, bred in the Punjab, has shown wide adaptability and high-yield potentiality.

Induction of Mutations

Realizing the value of mutagenesis in plant-breeding, a comprehensive programme was initiated at the Indian Agricultural Research Institute to exploit to the full the potentialities offered by mutation-breeding. Here the particular interest has been in the use of mutagens to rectify one or two specific defects in desirable genotypes. Following this technique, the character of awning was introduced into the varieties N.P. 798, N.P. 799 and N.P. 809. Again, the red-grain character of the high-yielding Mexican varieties, Sonora 64 and Lerma Rojo, was changed to the amber colour much liked by our farmers. The same objective can be achieved by hybridization followed by back-crossing but this, besides taking a much longer time, may lead to a dilution of desirable genotypes. This work has shown that, wherever possible, specific gene changes should be brought about by mutation research without disturbing the adaptive characteristics of the variety. Induced-muta-

tion analysis, undertaken by a team of enthusiastic research workers at the Indian Agricultural Research Institute, has also provided information of value in understanding the nature of genetic change involved in species differentiation and in reconstructing the phylogenetic history of the wheat plant as mentioned earlier.

The Future

It has become increasingly evident that in order to achieve a break-through in our wheat production, our efforts should mainly concentrate on evolving varieties suited to intensive agricultural practices, since the production records show that a major bulk of our wheat grains is produced in the rather small acreage having adequate irrigation facilities and high fertility. It is now known that the wheat plant can efficiently utilize much higher levels of soil nutrition and consequently give a much higher yield if lodging can be prevented. In Europe and America, the lodging problem has been overcome by breeding varieties with short, stiff straw. It is also clear from the work done in Mexico that reduction in plant height does not necessarily lead to a great loss in straw yields because the high-tillering ability of the dwarf strains acts as a compensatory factor. It is noteworthy that the 'Gaines' wheat, a dwarf variety of winter wheat developed in the USA, has created a new record for wheat yield in the world. So, our prime object should be to breed such dwarf varieties suited to Indian conditions and requirements. The outstanding performance of the Mexican dwarf varieties, 'Sonora 64' and 'Lerma Roja,' in comparative yield trials at Delhi and Ludhiana has shown that they may be directly utilized in wheat production in this country.

The development of hybrid maize and sorghum varieties which effectively utilize heterosis has revolutionized the yields of these two crops. Heterosis in wheat has been commonly observed and Briggle (1963) has recently published an excellent review of literature on cytoplasmic male sterility, fertility restoration, heterosis and cross-pollination in wheat as related to the production of hybrid varieties. It remains to be seen how economically the heterotic effect can be superimposed upon the yield base of the present highest-yielding commercial varieties.

Another exciting possibility has been the reconstitution of a hexaploid wheat by means of chromosomal or genome substitutions. A large number of amphidiploids have been synthesized by various research workers but none of them has so far proved worth the effort in spite of the high claims of their advocates. 'Triticale' and 'perennial' wheats have not proved as useful as they were thought to be.

The 'branched-ear' mutant of bread-wheat evolved by Dr. Swaminathan has impressed me. Ears of this mutant are sorghum-like and they contain nearly twice as many grains as those of the parental material. On improving expressivity of this mutant type by choosing suitable genotypic background, this 'induced' character may lead to development of 'miracle wheat' of future.

An outstanding cytogenetic contribution of present era has been the discovery that chromosome pairing in bread wheat is under genetic control.

This governing system of the diploid-like meiotic behaviour of the poly-ploid wheats, ensuring their high fertility, has been identified as being located in chromosome VA. In nulli-VA plants (i.e., in plants lacking the homologous pair of chromosome VA), multivalent pairing occurs among the corresponding chromosomes of the ancestral genomes leading to genetic recombination among homologous chromosomes. Thus, transfer of desirable genes through inter-specific and intergeneric hybridization can be effectively and more readily accomplished by taking advantage of this unique mechanism.

The Srinivasa Ramanujan Lecture 1964. This lecture was published originally in proceedings of the National Institute of Sciences of India, August 1966, and is reproduced here by kind permission of the Secretary, National Institute of Sciences of India

Science in Aid of Archives

Y. P. Kathpalia

DURING one's lifetime one creates and accumulates a large number of documents, such as letters, certificates of birth, education, marriage and taxes, land deeds, papers about investments and terms of contract. Such documents whether created or received by individuals or business firms or by government agencies or other institutions in the course of their work, are preserved either for their historical, cultural, legal or informative value or for research purposes. The greatest single creator of records is the government.

Documents may either be in printed or in manuscript form. They constitute the memory of the creating agency and possess a wealth of information. For example, they may provide a clue to the mineral and other resources or throw light on scientific, economic or social matters or on financial and legal commitments and other similar things. Because of this utility in records and their unimpeachable evidential value, documents have become the basic tools of administration. From whatever angle one may consider them, one cannot help but conclude that their conservation is necessary, not only for the use of the present generation but also for those to come.

The National Archives of India with its headquarters in New Delhi is one of the few archival institutions in the world which has a full-fledged preservation unit including a laboratory staffed with trained scientific personnel. The unit is furnished with almost all the equipment and apparatus required for conservation and restoration and for analysing and measuring the various physical and chemical properties of paper.

Writing Materials

Preservation of written records has certainly been a concern for learned people ever since the origin of culture. The fact that durable materials were actually employed for important records is sufficient proof of this concern. In the beginning the records were engraved on stone, brick or bronze. Later on, as a result of the desire to translate thought into writing, materials like papyrus, bark, parchment and leather were used. The dissemination of knowledge required the use of a substance which could be had in abundance at a low cost and be useful for writing purposes.

Paper fulfilled all these requirements admirably Since then, the advances made in the field of technology and scientific knowledge have helped its development and usage. Most of our present day records and those that have survived are on paper. However, like any other man-made material, paper is subject to deterioration.

Causes of Deterioration

Scientific research has shown that deterioration in paper is brought about by one or more of the following physio-chemical factors·

(a) Heat and exposure to light.

(b) Moisture; it is dangerous for its hydrolytic power. In addition, it favours biological attack.

(c) Frequent and pronounced changes in temperature and relative humidity.

(d) Acidic impurities, such as those present in the atmosphere of industrial areas, or in dust. Likewise strong alkalies are also injurious and contribute to the deterioration of paper.

(e) Oxidizing agents.

(f) Presence of heavy metals even intraces They catalyze oxidative degradation and also the formation of sulphuric acid from the sulphur dioxide present in the atmosphere.

(g) Presence and use of acidic sizes, such as alum, rosin etc. and of acidic ink.

(h) Use of fibres having low content of cellulose and presence of non-cellulose materials of the lignin type, which are often acidic in nature or yield acidic derivatives upon decomposition. Such non-cellulosic materials are sensitive to deteriorative agents such as light.

Deterioration caused by the various agents enumerated above, viz. light, heat, moisture, dust particles, insects and acids, is different from deterioration associated with the normal ageing of paper. All papers, irrespective of the materials of which they are made must deteriorate with age, in spite of the most ideal storage conditions. Such deterioration can only be minimised or at best retarded.

Conservation

Deterioration due to all these causes can be counteracted by taking preventive steps and this is what constitutes conservation of documents. For preservation on scientific lines, the primary task is to have men who have intimate knowledge of the different types of paper, their mode of production, the effect of environmental conditions on them and the materials used for creating records, and also on those used for enhancing their longevity, for example, inks of various kinds, cardboards, parchment, vellum, leather, textiles, cellulose plastic films, adhesives. A person engaged on the conservation work must, therefore, have knowledge of physics and chemistry besides that of architecture and entomology.

The physical properties of paper are measured by instruments devised to simulate the main types of strain the paper may or is likely to undergo when in use, such as, folding, tearing, bursting, tensile etc. The effort required to break the sample is usually taken as

its significant value. These determinations are of course generalized, that is, a paper withstands foldings say eighteen-times only. This test, however, has a high practical value when, for instance, it predicts that one paper will withstand use longer than another of a lower folding endurance as measured by the instrument.

The chemical properties relate to composition, fibre quality etc. They are very important because the dependence of durability of paper upon composition has been definitely established. Also some chemical properties are related to mechanical strength and hence to durability of paper. For example, the mechanical strength in paper depends upon the length of cellulose chains, which can be determined chemically. One of the effects of deteriorating agents is the breakdown of the large chains of cellulose molecules. The keeping quality of paper is also dependent upon the free acidity in paper. Determination of this free acidity helps to evaluate the ageing of paper.

Facilities also exist in National Archives, New Delhi for deciphering of charred, water damged or disfigured documents, for ultraviolet and infrared photography, microfilming and photoduplication work.

During the past fifteen years or so, much work has been done all over the world on various problems of conservation and restoration of documents, such as in the field of restoration, neutralization, use of adhesives, paper testing, formation of standards etc. To describe a few:

(a) *Solvent Lamination Process:* This process was developed in 1953 in the National Archieves, New Delhi and is now known all over the world as the Indian Process of Lamination. In this process sheets of cellulose acetate film and tissue paper are placed on either side of the document in the following manner:

Tissue paper
Cellulose acetate film
Document
Cellulose acetate film
Tissue paper

Acetone is first applied to the sandwich of the document in the centre suing a non-linting cloth and then wiped towards the edges. The procedure is repeated on the other side. The laminate is then pressed in an ordinary binder's press. In this process no heating is required.

It has now become a standard technique for restoration of documents and has been adopted by a number of archival institutions all over the world; the usefulness being limited only by the skill of the processor. It compares favourably with the machine process, developed in USA, where heat and presure are used. Commenting on this process, Dr. Joh Papritz in the International Council of Archives meeting in Stockholm stated, "....it seems that a suitable solution has been found for lamination in the restoration of single document which will soon spread to archives all over the world." He further stated that it is the only hand process for applying synthetic foil and that it will probably make all other low temperature processes superfluous.

(b) *Development of India-7*: The efficacy of this process has been enhanced by its successful mechanisation by a French firm, *Omnia Industrie,* Paris. The firm has named the machine

India-7 in honour of the country where the process was developed. There are two models of the machine. One permits treatment of the document on individual basis and the other permits an automati cturn-out of restored work.

(c) *Non-Woven Fabrics for Restoration Work*: Experiments have been conducted with synthetic non-woven materials with a view to replacing issue paper in the conventional sandwich, described earlier under solvent lamination. The work has shown that terylene tissue paper is suitable for such work. Samples laminated with it, come out much cleaner and lighter. It has been observed that much less quantity of acetone is required for the job. Further, it has greater tearing strength, more flexibility and greater folding endurance than the one laminated with tissue paper. The repair sample is much more mechanically and chemically homogeneous than the conventional sandwich and therefore, not liable to unbalanced streasses due to change in the moisture content and temperature of the atmosphere.

(b) *Neutralisation:* Acidity is one of the causes of deterioration of paper. It is essential to neutralize it prior to effecting restoration. A number of processes involving the use of substances such as calcium carbonate, magnesium carbonate, ammonia, and cyclohexylamine carbonate have been described in the literature.

A process that has been studied recently involves the use of the sodium salt of carboxy-methyl cellulose. It has been observed that the neutralization effect, brought about as a result of the use of this material, remains even after heat-ageing. However, the treated paper becomes stiff. It was observed that if a non-volatile plasticizer is added to CMC, which is a polymeric cellulose derivative, it helps to maintain the flexibility of the treated paper. It was also noticed that the folding endurance of the treated sample is increased to such an extent that the fold-endurance even after ageing remains almost superior to that of the original untreated paper.

(c) *Adhesives:* A thorough study of various natural as well as synthetic adhesives has been made by the International Council of Museums, and a UNESCO sponsored body. As a result of this a number of synthetic adhesives which can be used safely for conservation work have been detailed and described. Another study conducted by the author in 1965 emphasized the use of alkaline adhesive for the repair of old documents. The use of alkaline paste is now being recommended and adopted universally.

(f) *Formation of Standards:* A number of papers in use in the various offices of the Government of India were tested by the author and found to be of inferior quality. The efforts of the National Archives since then have resulted in a standard for permanent record paper. The standard was published by the Indian Standards Institution in 1961. Paper made according to the specifications laid therein is expected to have reasonable durability and lasting qualities.

However, Mr. W. J. Barrow of USA has developed a printing paper which is expected to last for about 300 years. His study was sponsored by the Council of Library Resources Inc. of USA.

This paper is composed of well purified chemical fibres—one third sulphate, one third sulphite and one third soda. It is filled with 10% clay and 10% calcium carbonate added in the heater. It is machine-sized with Aquapil—a size compatible with alkalinity. It is surface sized with a 7% starch solution and has a pH of 9.00 (cold extraction). It is estimated that after ageing for 36 days at 100°C, 40% of fold and 75% of tear values will be retained, thus giving a theoretically useful life of at least 300 years.

Miscellaneous Work

An interesting phenomenon has been noticed with old papers recently. It has been observed that when the cut or shreded portion of an old paper is covered with water and if a ring of filter paper is inserted to act as a wick for eluting and concentrating, the water soluble material a brown ring besides others is found on the top half-inch of the ring of filter paper. This water soluble material has been analyzed and found to have a formula $C_{12}H_{18}O_{10}$ (M.W 322). The experiments were repeated with papers of known composition and date of manufacture. After ageing them for 9 days at 105°C, it was observed that rings were found on the filter paper which were similar to the ones obtained with old paper.

It is well known that the age of a tree can be determined by the number of concentric annual rings in the trunk of the tree. On the analogy of this, can the age of paper be determined from the analysis of the organic compound in the rings obtained from old paper? Work on this line is in progress. A breakthrough will provide a new process of dating of old documents.

The other problem that needs careful study is availability of proper type of materials suitable for conservation and restoration work. These days because of the advance in technology many synthetic materials are being offered for the work. Indiscriminate use of such materials is likely to result in more harm to the document than good. The only sure way is a complete scientific investigation.

To those who ask, what is a chemist doing in an archive, it may be said that his is a constant vigil and war against the deteriorative agents of paper for safeguarding the nation's cultural heritage for years to come.

Microelectronics Today

B. H. Venning

THOSE familiar with the development of electronics over the past fifty years think of miniaturization as a trend that has long continued. The original valves made the electric lamps, but then developed towards the miniature and sub-miniature forms still in use in many stages of television receivers and hearing aids. Mobile transmitting stations which originally required a cart or van to achieve mobility evolved to man-pack or hand-held walkie-talkie sets, whilst receivers were reduced to handbag-size transistor sets.

Why, then, has the advent of microelectronics in the past few years created such interest and caused much head-scratching concerning the ultimate changes it will cause in the electronic world? The obvious factors of reduced size and weight are significant only in some applications, such as computers for satellite, rocket or airborne use. The smallest size of many pieces of equipment is governed by such items as control knobs, and interconnection plugs and sockets. A radio receiver, for instance, has to carry tuning and volume controls which can be manipulated, a dial which can be read easily and a loudspeaker large enough to reproduce at least some notes faithfully. For microcircuits to have any impact on the domestic television market, the advantage cannot be in the 'micro' aspect as the size of the set is determined by the viewing screen area, and not by the associated circuits.

The real causes of the impending revolution are to be found in the factors of improved reliability and the expectation of more economic production once large numbers of such circuits come into use. For the first time a number of active devices (the power-producing transistors) and passive components (the resistors and capacitors that determine the function of a circuit) can be fabricated at the same time within a single package, in a controlled sequence of operations that then produce the complete circuit. Previously, assembly has always been from individual components, each one soldered into position even if the interconnections have made use of pointed circuit-wiring. Small components have produced miniature assemblies, but handling difficulties obviously limit the ultimate reduction in

Reprinted from the Times Science Review, Winter, 1965.

size. Microminiaturization is now accepted as starting at a packing density exceeding five parts per cubic inch, which can be achieved with sub-miniature conventional components carefully assembled in random or uniform geometry. At this stage, reached some years ago, the main difficulty was to make satisfactory interconnections in the limited space available. Now the earlier methods are overshadowed by the production of truly integrated circuits developed from techniques used in transistor manufacture, achieving packing densities of 200-1,000 components per cubic inch in production equipment, and up to 10,000 in experimental items. The microcircuit modules are produced under conditions where absolute control of purity is essential, and the small weights of material involved allow the liberal use of precious metals such as gold. A number of components are produced on a single sheet, complete with interconnecting paths, so the number of joints is a minimum and most of these concern only the external circuits. All these conditions foster good reliability, and as automation is essential for the production process, the economics are favourable once large-scale use is achieved.

The basic manufacturing techniques employed produce either thin-film circuits (T.F.C.), semiconductor integrated or 'solid' circuits (S.I.C.), or hybrids combining the most desirable features of both. The passive components (the resistors, capacitors, and inductors of low value) of a T.F.C. together with the interconnecting paths, are formed by deposition of a thin, conducting film on a flat glass or similar substrate. It is not yet possible to form active semiconductor devices on a commercial scale by the same means; so transistors and diodes of suitably small dimensions have to be attached to the substrate separately, but not necessarily by hand as the process can be automated. This type of circuit is most suitable when the ratio of passive to active components is high and when the values of the passive components have to be accurately controlled.

Solid or semiconductor integrated circuits have grown out of the planar process used for transistor manufacture, which lends itself to the production of a large number of transistors (possibly several hundred) on a single silicon slice, an inch in diameter. This same area of silicon can be devoted to a mixture of transistors and diodes with interconnecting paths formed by zones of specified resistance. Three-dimensional geometry allows the production of 'cross-overs' where paths cross without resistive connexion, and capacitors can be formed from parallel films or from semiconductor junctions. The function of the different zones is determined by selective 'doping' in successive operations, and the circuit is indeed solid, with no external connections to be formed between active and passive components. A typical combination of nine active and six passive components constituting a high-gain low-drift amplifier, occupies a chip size only 0.05 in. by 0.05 in. before encapsulation. There are certain limitations in the values of resistors and capacitors which can be obtained, and control of these values is not as precise as with a T.F.C.; so this type of circuit is at present more acceptable for a high value of active to passive components, although it is also being

used with great success in feedback amplifier circuits such as the example just quoted.

There are obvious situations where it is desirable to combine the best features of both types, leading to hybrid circuits which contain passive components of critical values formed as a T.F.C. on a substrate, with the active devices and less critical components formed as one or more S.I.C. chips. In all these circuits, the larger values of capacitors needed for electrical decoupling and nearly all inductors have to be added as external units, as these cannot be incorporated in integrated form. One difficulty experienced with silicon circuits arises when it is necessary to ensure isolation between adjoining transistors, and dielectric regions have to be added if the original monolithic structure is to be maintained. The circuit can, however, be divided physically into separate chips which are then remounted on a non-conducting substate. Isolation is now achieved at the expense of introducing more interconnections between the various chips and to the external pins. The final encapsulation of either type of circuit can be a miniature TO-5 transistor can (0.25 in. diameter) with leads emerging from the base, or one of several plastic 'flat packs' of a size dictated by the enclosed substrate, and connexions taken *via* rigid pins at the sides.

The basic operation involved in producing a T.F.C. microcircuit is to deposit a suitable pattern of a thin conducting film of the correct dimensions on an insulated substrate, together with the necessary internal interconnections. The substrate is usually a highly polished flat sheet of borosilicate glass (typically 0.05 in. thick) similar to a microscope slide, or a sheet of alumina glazed with a similar glass, the alumina being introduced to provide better thermal conduction to a heat sink. Deposition on to an active substrate silicon, is also used in the preparation of hybrid circuits.

A typical sequence of operations is as follows:

1. A conducting layer of nickel-chromium, or of a silicon monoxide/chromium mixture is formed on the substrate by vacuum deposition, i.e., by heating in a vacuum chamber in which the required metal is evaporated from a separate crucible.

2. This layer is coated with a photo-sensitive lacquer (a photo-resist), and covered with a photographic negative, prepared by suitable reduction to define the required pattern.

3. Exposure to ultra-violet light produces a light-hardened image which can be developed to give an exact copy (0.0001 in.) of the required pattern as a protective layer on top of the thin film.

4. Etching in a solvent dissolves unwanted metal to expose the bare substrate, and the photo-resist is then removed by a further solvent to leave the required pattern of metallic resistors. The dimensions can finally be adjusted, if necessary, by cutting with a suitably directed jet of fine abrasive.

5. Interconnections of gold, aluminium or manganese can be formed by depositing one of these on top of the nickel-chromium, followed by selective etching to form the required pattern.

The sheet resistance of a typical layer of nickel-chromium, 100 angstroms thick is 100 to 300 ohms/square (this being

independent of the choice of linear units), while that of cermet is at least ten times larger. Resistors from 25 ohms to 100,000 ohms can be obtained to five per cent tolerance. Capacitors are formed by a series of selective etchings that leave a bottom electrode of gold (or aluminium) covered by a dielectric of silicon monoxide and a top electrode of aluminium, obtaining values of 20-200 picofarads. Inductors have to be made from a spiral-shaped pattern and only small values below 10 microhenries are possible, which nevertheless find applications in many radio-frequency circuits operating between 10 and 100 megacycles a second. All the components so produced have good tolerance (five per cent), high stability and a low temperature coefficient (less than 0.2 per cent per degree centigrade), i.e., they can be classed as 'high quality.'

Active devices for incorporation in thin-film circuits are either normal transistors encapsulated in small cans (0.125 in. diameter) or are specially constructed to have the three electrode connections on the same face, so that the chip (a 'flip-chip') can be mounted directly on to a suitably prepared region o fthe TFC using automated assembly. Much experimental work is in progress to produce the active devices directly by thin-film techniques, but this is not yet a commercial proposition.

The final substrate, complete with any added components and active devices, can either be encapsulated on its own to form a flat-pack with leads spaced around the edges, or combined with other prepared substrates to form a packaged module, equivalent to perhaps 500 or more conventional components, in a few cubic inches.

Another recent development introduces 'thick' films instead of thin ones, utilizing screen printing techniques to produce the required pattern. The degree of control is not as high as in the vacuum process, but it should be more economical for small quantities as the complicated vacuum equipment is not required.

Solid Circuit Technology

The semiconductor (or silicon) integrated circuit, or 'solid' circuit, is truly integrated in the sense that both the active and passive devices are manufactured from a silicon wafer by diffusion processes developed from those used in the manufacture of planar epitaxial transistors. This method has, over the past few years, become the most satisfactory way of making high-frequency low-power transistors at an economic price, and as the physical dimensions of these must be small to obtain the good frequency response, they are manufactured in a large number (possibly 200 or more) on a single wafer of silicon a few square inches in area, before being separated for selection and encapsulation. The term 'planar', or surface passivation refers to the use of a chemical film layer (silicon oxide) over the surface of the semiconductor material to provide electrical and chemical stability; diffusion is allowed to take place only at selected areas *via* holes etched in this surface. Epitaxial growth is used to provide a layer of high-resistivity silicon at the active surface of a low-resistivity wafer, the transistor junctions being grown in this region, giving an improvement in both high-frequency and switching performance.

The planar process involves.

1. Preparation of the surface of the silicon substrate, about 0.015 in. thick.
2. Oxidation of the surface layer to silicon dioxide, by passing steam over the heated wafer.
3. The formation of suitable holes in this protective layer by photo-engraving, using masks, photo-resist and etching as for thin-film circuits, except that the photo-negative now carries multiple images to prepare a large number of devices at a single exposure.
4. Diffusion of a suitable doping material from a gas into the heated substrate.
5. A repetition of the above *via* different masks and using different doping material to form the various active regions, finally adding the contact areas.

The production of integrated circuits simply involves the substitution of regions of suitable dimensions to act as resistors, conductors and capacitors connected between adjoining transistors and diodes. No large changes in techniques are involved, but considerable ingenuity can be employed in the layout to obtain suitable bridges for cross-connections, and to isolate adjoining active regions. A typical strip prepared for a resistor will have a sheet resistance of 100 ohms/square, of a similar order to that of a thin-film resistive layer, so geometric dimensions are similar. Widths may be as low as 0.5 to two thousandths of an inch, but the best tolerance obtainable is 20 per cent, and the thermal sensitivity of the silicon leads to temperature co-efficients of 0.1 per cent per degree centigrade, or about ten times that of thin films.

The monolithic silicon circuit, with all its active components on the same wafer, suffers the disadvantage of poor isolation between regions because it is not possible to obtain very high values of resistance, and there is a basic capacitative coupling inherent in the semiconductor junctions formed in the processes. Imporved isolation can be obtained by introducing regions of dielectric between the active devices, but in many cases it is better to cut the original wafer into individual chips, remounting these on a passive substrate. This entails additional interconnections, thereby throwing away one of the advantages of solid circuits, but if this penalty is accepted then the hybrid circuit results. The most desirable features of the two techniques can then be combined, coupling the high-quality components of the thin-film circuit with the cheaper, less precise blocks of the solid circuit.

Reliability and Economics

The reliability of a conventional electronic system is all too often rather poor when it contains tens of thousands of passive and active components and hundreds of thousands of joints, whether they are formed by soldering, welding or wrapping. To eliminate many of the joints, produce all your components under identical conditions of high chemical cleanliness from ultra-pure materials, encapsulate them to avoid atmospheric contamination and finally make them all so light that mechanical shock imposes only the minimum of vibrational forces—and the main causes of unreliability must disappear. Microcircuits do just these things, and the reliability of equipment using them can be expected to be superior to that obtained from conventional circuits, although this point obvi-

ously takes time to prove.

Unless the application is such that the advantages of small volume and low weight outweigh all other considerations, microcircuits of any type are only justified economically if large enough quantities of similar types can be produced. Such production runs are the dreams of every manufacturer. They can be obtained most easily in the construction of digital-type equipment, which utilizes large number of identical logic circuits. Hence, ranges of these are available from many manufacturers, at prices not greatly in excess of the cost of construction from individual components. For amplifier-type circuits, some basic combinations are available at similar prices, but it becomes difficult to specify circuits which are basic enough to be made in the large numbers necessary for economic production.

The employment of integrated circuits of any type leads to a problem of system design rather than one of circuit design, which has been the traditional approach of the circuit engineer until the past few years. The customer who buys the modules from the shelf is no longer concerned with the correct adjustment of the condition of individual transistors, his prime job now being to ensure the correct matching of one module to the next, adding external components where necessary to evolve a system which satisfies the desired specification. An engineer concerned with manufacturing the devices meets an even greater challenge: his circuit design must now be integrated, quite literally, with fabrication techniques.

The last few years have seen the introduction of several new British computers using integrated circuits in quantity, some using imported devices while others are manufactured completely in this country. The makers of microcircuits are busy producing cost graphs showing optimistic projections into the nineteen-seventies when it is anticipated that the cost per unit will be considerably less than that today. At the present time the economic advantage arising from their use is only marginal. This is essentially an evaluation period for the equipment manufacturer on the commercial side and for service users on theirs, for testing the claims of the producers, particularly the all-important reliability aspect, and for matching the economics of using the devices at their present cost against the more traditional manufacture from individual components.

There is every indication that the claims will be substantiated, and that better and cheaper equipment of many categories will result, in which case integrated circuits will become the accepted technique for use in any equipment in quantity production.

Methods of Teaching Science Subjects

V A. GLUSHENKOV I. D. ZVEREV

N. K. SANYAL

THE main objectives of teaching science subjects at the school stage are to give pupils systematized knowledge of the bases of science, to ensure that they comprehend scientific facts in the light of modern theories, to develop in them certain experimental and manipulative skills, and to enable them to acquire a scientific outlook. The UNESCO Experimental Project therefore attaches great importance not only to the proper selection of material (content of teaching), but also to the choice of teaching methods for achieving these objectives.

A lesson in any science subject may be taught by any one of the different methods of teaching discussed below or by a combination of two or more of these methods.

Let us examine the various methods of teaching and their classification and consider their use according to the specific character of the contents of the school subject.

Methods of Teaching and their Classification

The word 'method' in Latin means 'mode' or 'way'. This word may express various meanings. In pedagogics it means the method by which the material to be taught is communicated from the teacher to the pupil.

The teaching methodology of a subject is a pedagogic science and it is closely interwoven with the content of the subject. In teaching a science subject, the following problems are involved: Why do we teach? (aim and tasks of education in that subject); What do we teach? (content of the subject); In what way do we teach? (methods of teaching and organization of the school programme); How do children study? (the process of learning).

Hence the problem of methods is of great importance.

Methods of teaching may be defined as the methods by which the teachers impart knowledge and skills while teaching, and the pupils comprehend the knowledge and acquire the skills in the process of learning.

This definition emphasizes the fact that the process of teaching is a two-way process and is composed of teaching (teacher's activities) and learning (pupil's activities). There exist several methods of teaching and they need

classification. They may be classified in the following groups:

I. Verbal methods (narration, lectures, talk etc.).
II. Methods employing visual aids in teaching (observations, the demonstrating of charts, films, slides, models etc. by the teacher).
III. Methods of practical teaching (laboratory experiments, laboratory work, preparation of apparatus and models etc.).

Pedagogic research convincingly proves that we can not exclude any one of them, and that all the three groups of methods of teaching are to be used in combination. Still we choose one of them as the main method in a lesson. If the pupils react quickly to an object then the teacher uses the practical methods. If it is enough to demonstrate an object or its image, the teacher chooses observation methods. Let us discuss each of these methods in details.

I. Verbal Methods.

The 'word' is one of the main sources of knowledge. The teachers and pupils widely use oral and written speech in the process of teaching and studying science subject. A word, uttered and heard, really gives an abstract concept. According to Pavlov, the Academician, "word being so characteristic of man is already abstract in itself".

But one should not confuse verbal methods with verbal teaching. By 'verbal teaching' we mean such a method of teaching in which no other methods but oral are employed (teacher's narration and pupils' reaction). Oral methods of teaching differ from 'Verbal Teaching' since they are used in combination with other methods.

We distinguish the following forms of the oral method of teaching:

1. Narration.
2. Lecture.
3. Talk.
4. Work at a book.

1 & 2. Narration and Lecture: They envisage one-sided delivery of material by the teacher or pupil. The term 'narration' is applied to the act of describing objects, explaining the essence of phenomena and the processes. It makes pupils comprehend the new material systematically. For example, narration may be adopted when the teacher wants to tell pupils about the structure and functions of a certain system of organs in biology. In this case the pupils actively listen to the teacher, visually comprehend the demonstrations, and make drawings and sketches. By active listening, is meant pupils' concentrated attention, their ability to give correct answers to questions put by the teacher in the course of the lesson, and to express their opinion etc.

Verbal narration, as a rule, contains: introduction, narration itself and conclusion. Introduction aims at motivation, brings in the aim of narration and attracts the pupils' attention. Then comes the narration of the new material in right sequence. The conclusion should be aimed at generalization and systematization of the introduced material. The teacher's narration should be simple for pupils' comprehension. With this aim in view, the teacher should report in clear and distinct expressions avoiding a large number of

special or technical terms. It is necessary that the new material should be correlated with the previous one, already known to pupils from previous lessons or their life experience. For example, in class VII while introducing 'oxygen' the teacher refers to the knowledge already accumulated by pupils, and reminds them of the experiment of heating mercuric oxide and the liberation of oxygen. He tells them that the Swedish Scientist Scheele for the first time obtained oxygen in 1771. Later on, the same experiment was repeated by the English chemist Priestley, and then the French scientist A. Lavoisier who studied the properties to this substance and named it oxygenium-oxygen. Then one may narrate the chemical properties of oxygen.

Thus pursuing the principle of combining teachers' word with the demonstration of a phenomenon, a natural object, or its model, it may be emphasized that the teacher's narration should be closely interwoven with visual aids, demonstrations and laboratory experiments. A pure lecture is very rarely used in teaching science in school. A lecture is characterized by more complicated contents and is usually applicable to the senior classes (IX-XI).

In general, a lecture has much in common with narration. It should however be illustrated by visual aids, demonstrations, laboratory experiments, films etc. A school lecture comprises complicated generalizing material of theoretical character (for example, valency of elements based on the theory of the structure of atoms in chemistry, theories of evolution in biology. Law of conservation and transformation of energy in physics). It may be devoted to a description of the scientific activity of an outstanding scientist (for example, D.I. Mendeleyev's discovery of the Periodic law in chemistry, Darwin's contribution to biology).

The following important requirements of narration and lecture should be kept in mind.

1. Figurativeness, vividness, picturesqueness of delivering.
2. Sequence of ideas in explaining the main problem.
3. Validity of concepts and ideas by examples and facts, making conclusions, summarizing.

The pupils should be taught to deliver narrations and lectures to their classmates.

But both narration and lecture are always used only in combination with the other methods. During a narration or a lecture, the teacher should demonstrate experiments, show models, charts, natural objects etc. This is the correct way from the point of view of methods of teaching.

3. *Talk:* Pupils activity is high when the introduction of new material is brought about with the help of another type of verbal method, a talk, which envisages a sequence of well thought-out questions, put to pupils during the teaching process.

Talk may be delivered at a lesson—in case:

(i) It is possible to refer to the previously received knowledge.
(ii) It is possible to refer to pupils' life experience.
(iii) The teacher is demonstrating an object.

In most cases a talk is addressed to the whole class, which acts as a collec-

tive interlocutor. In a talk one can witness pupil's active participation.

Talks may be of several kinds. From the point of view of pedagogy, an "heuristic" talk which makes pupils draw conclusion from available data, is very valuable. Similarly while generalizing and systematizing pupils' knowledge 'generalizing talk' and while checking and estimating pupils' knowledge 'control talk" may be employed. The aim determines the type of talk. But strictly speaking one can not be differentiated from the other. Thus heuristic talk envisages a system of questions answering which the pupils themselves come to comprehending chemical or physical phenomena and to certain conclusions. Heuristic talk is extremely useful when the material has accumulated reasonings.

Suppose the teacher delivers a talk on the morphology of a bean seed (VI class botany). All the pupils are given bean seeds, after that the teacher asks, —What is it that covers a seed?

Pupils: Coat, peel, veil etc. (the teacher chooses the correct answer.)

Teacher: What is the colour of the bean seed?

Pupils: Brown, black etc.

Teacher: What appears when the coat is peeled off?

Pupils: Two halves.

Teacher: These are two cotyledons; move them apart, what is there between them?

Pupils: Leaves, bud, rootlet, tendril.

Teacher: Examine through a magnifying glass and find out to what is the bud attached.

Pupils: To a stem.

Teacher: What is the structure of the bean seed?

Pupils: The seed is covered by coat. It consists of two cotyledons, has a rootlet, bud and stem.

Now the teacher asks the pupils to write down their conclusion and to sketch the structure of the bean seed. For the sake of recapitulation the teacher may ask pupils to enumerate and show on a chart the parts of the seed. This talk is closely interwoven with practical work.

A talk may be based on the demonstration of an experiment, a chart etc. The teacher should always take care to ask the correct questions in right sequence. Having estimated the answers, he should be able to compose new ones.

Generalizing talk summarizes, systematizes and consolidates pupil's knowledge. For example at the end of the lesson 'Molecular structure of substances' (VII class chemistry) the teacher puts the following questions serially:

(1) What experiments can prove that a substance is composed of very very tiny particles?
(2) How can it be proved that molecules are always in motion?
(3) What is diffusion? Give some examples.
(4) Explain what happens: when exposed water evaporates in a tray, or smell of spilled benzene spreads.

From the very first lesson pupils should get accustomed to the idea that all the material introduced by teacher should be understood during the lesson. This load need not be shifted to home-task. At home pupils have only to consolidate the material read by them in the text book.

The consecutive realization of this requirement will result in the active participation of pupils in the teaching process.

4. *Work at a Book:* Developing pupils' ability to work at a text and picture must become a part of the process of teaching. They should be able to work at a book not only in school, but at home as well.

It is important that the teacher should organize a variety of work at a text-book for pupils.

(i) *Retelling of the text:* This method is often resorted to at school. It helps pupils consciously comprehend the contents of the theme, promote their speech and thinking. Retelling of a text should begin with most easy material (e.g. monographic description of a plant, its application, characteristics, structure of its parts.)

(ii) *Explanation of pictures and sketches:* This type of work envisages. Pupils' enumerating the parts, for example, of a seed (all the labellings should be covered with a piece of paper); checking of the fulfilled task; describing the outer structure of a tree from its picture; detecting by schemes the corresponding pictures of flowers etc.

(iii) *Answering questions:* The teacher may resort to the questions given at the end of each paragraph or frame his own questions. Teachers' putting questions on the text and pupils' answering them are very useful.

(iv) *Working out of a plan to the text.* The teacher employs this method when pupils work at a complicated text, embracing a number of difficult problems (e.g., composition and properties of soil; types of stems; types of vegetative reproduction). A plan may be composed by pupils to the paragraphs dealing with generalization and deduction.

(v) *Looking for some additional facts:* e.g. pupils may refer to monocotyledonous and dicotyledonous or to plants having different type of roots.

(vi) *Conducting of an experiment or observation according to the textbook:* Textbook instructions and tasks help pupils integrate and comprehend theory and experiment. Thus, pupils may conduct experiments showing the importance of water and air in seed germination; evaporation of water from leaves; results of root grafting; forming of the crown of a tree.

Work at a textbook is closely interwoven with pupils' work at his notes. Pupils may prepare notes and sketches in their biology note-book not only during the lessons, but at home as well. Such notes and sketches may be on:

1. Writing down of the syllabus and lesson themes:
2. Writing down of the plan of the lesson and sequence of main problems:
3. Writing down of hometask.
4. Writing down of deductions and conclusions:
5. Composing of comparative schemes and classification charts.
6. Sketching of the schemes for setting an experiment; fixation of the results of an experiment.
7. Writing down of independent work; book review etc.

It should be always kept in mind that pure verbal methods lead to pupils' memorizing words without correct and concrete visualization and comprehension of objects and pheno-

mena described by the words. To achieve a correct forming of ideas and notions it is necessary to combine verbal methods with illustrations and demonstrations, visual aids and practical works and experiments.

II. Methods Employing Visual Aids in Teaching

The demonstration of objects by teacher is widely used in teaching a science subject. The methods of observation are of utmost significance in this method.

Observations

Demonstration of objects and phenomena, charts, drawings, models etc. must be widely used in a lesson. This helps pupils comprehend the introduced material correctly and profoundly. Methods of observation are based on the combination of word and image.

A folk proverb runs: "To show once is better than to narrate ten times". Methods of observing envisage interweaving forms of activities, demonstration by teacher and comprehension (observation) by pupils. Hence, while using methods of observing one should stress the unity of teaching and learning.

There exist three forms of their combination.

1. Image before word.
2. Word before image.
3. Word and image interwoven.

Psychological research has proved the first and especially the last forms being most effective from the point of view of pedagogics.

The uses of visual aids should satisfy the following main requirements:

(a) A demonstrated object or its expression on a chart should be well observed by all the pupils. Therefore its dimensions or scale should be taken into consideration.

(b) Small objects and chemicals should be distributed among pupils or shown by teacher to each of the pupils.

(c) During demonstration pupils should have in front of them only the necessary visual aids.

(d) Diagrams of processes of production facilitate the formation of pupils' concepts only when they focus their attention on the main and substantial problems from the point of view of studying general principles of technological production. In building up concepts of industrial processes models of typical apparatus are of great aid. They may be made of various material: plywood, paper, tin etc. A model should be made of the disassembling type, giving an idea of the outward appearance and the inner structure of an apparatus. While making models one should keep in mind the scale and general diagrams of processes of production and of apparatus. Models may be made by pupils during the Science-club activities.

The four means of observation are through:

(i) Demonstration of natural objects;
(ii) Demonstration of charts and models;
(iii) Chalk drawing;
(iv) Demonstration of slides and films.

Let us now examine all these forms.

1. *Demonstration of natural objects:*

Pupils' knowledge of science is incomplete and formal, if they are not acquainted with the environment of the theme. The teacher should demonstrate during lessons, natural objects, (for example plants and animals in biology, natural gases and ores in chemistry). This facilitates study of nature in its natural forms.

It is very important that a complete observation of the appearance of live objects be arranged for the study of the properties and features. Animals that cannot be observed in real life should be shown as dead specimens (e.g. in museums).

Demonstration of natural objects rouses great interest in pupils, impresses them and promotes the building of a sound knowledge. The teacher should always plan beforehand the chain of questions for a talk with the class that is being conducted on the basis of observation of live objects. Small objects (e.g., plants) should be distributed among pupils for study according to certain instructions. Almost at each lesson, the teacher.) should demonstrate natural but not necessarily live objects (herbariums, stuffed animals, skeletons, collections, chemical substances, physical apparatus etc.) It is very useful to distribute these objects among pupils, to outline the aims of observation, to give questions for answering and to draw conclusions out of the analysis of the facts accumulated in observing objects.

Observation as an independent method is used in studying physical and chemical properties of substances and industrial processes. For correct description and memorization of the properties of substances and their correct visualization, it is necessary to demonstrate substances both in their natural state and in the state we often see them in our every-day life. Solid crystalline substances should be first demonstrated in their solid and crystalline state, and not as solutions; while liquids should be first shown as liquid. When pupils are acquainted with the solid and crystalline state of a substance, its solutions may be used. Such a successive introduction of substances helps us avoid errors like 'blue vitriol is a blue liquid', 'caustic soda is a colourless liquid'.

Experience shows that due to incomplete or imperfect instructions, the pupils comprehend and describe physical properties of substances in a wrong way, paying great attention to only one particular property. Pupils often say that sulphur is yellow, but seldom speak of its aggregate state; that sugar is sweet—but do not mention that it is crystalline. A teacher should teach pupils how to observe correctly and describe their own observations. With this purpose in view the teacher should map out the plan of observation to canalize the comprehension of the new material.

The difference in comprehension and description of the properties of substances by one and the same pupil before and after his getting acquainted with the methods of observation can thus be seen (in both cases it is assumed that he has got a set of the necessary substances and equipment).

1. Before his getting acquainted with the methods of observation: Sulphur is a yellow substance of a certain shape.
2. After his getting acquainted with the methods of observation: Sul-

phur is a yellow solied, brittle and a crystalline substance. Crystals of sulphur sink in water, while as powder it floats on the surface. Sulphur does not dissolve in water. Sulphur slightly smells. On heating for sometime, it melts.

Observation is often very closely inter-woven with practical methods.

2. *Demonstration of charts and models:* If it is not possible to demonstrate natural objects, the teacher should resort to visual aids. Charts, models etc., are used in combination with demonstration of natural objects. A model or a chart emphasizes some phenomenon or property, thus facilitating its detailed study and comparison with the natural object.

For example, we may take a model or a chart of the morphology of a flower and its parts, a dissection of a frog's heart and a model of a heart; a stoma under a microscope and a model of the action of the cells of a stoma, the charts and models of plants of industrial productions in chemistry. Appreciation must be developed in models about the comparative size of the model and the actual size of the specimens or objects. The effectiveness of a chart depends on the emphasis on certain points that are needed for developing the lesson.

3. *Chalk drawing* is widely used in the process of introducing new material or recapitulation. It focuses pupils' attention on the main features and promotes building up of spatial ideas. A drawing must be simple, expressive, legible to single out the most significant features of an object. A drawing on the blackboard should appear simultaneously with explanation or oral introduction.

For example: A schematic drawing of the structure of a cell may appear little by little simultaneously with the main features. To complete the drawing, teacher should label the parts of the cell.

Drawing may be: (i) symbolic, (ii) schematic and (iii) realistic.

The teacher should use coloured chalk to distinguish parts of an object. All labels should be neatly given. Pupils should start copying into their copybook after the teacher finishes sketching and explaining the new material.

4. *Demonstration of slides and films:* Slides and films reproduce nature, facilitate comprehension of material irrespective of place and time and portray the dynamics of the phenomena. They bring things in the classroom, which cannot be seen or visited by pupils personally.

It should be emphasized here that a film should be always subordinated to the contents of a lesson. Before projecting a film, the teacher should assign some task and if necessary give short explanations while projecting a film; discuss the projected material (talk, narration, new examples, written answers).

It is advisable to project films by fragments. It helps teacher check pupils' comprehension of the film, locate the most difficult problems, introduce complicated concepts by parts. Having reviewed a part, the teacher conducts a talk, the pupils make sketches and observe other demonstrations. Thus, projection of film is closely interwoven with other auxiliary methods. Films are used as accessory study material but not as independent ones.

III Practical Methods

Visual aids display to a certain extent the properties of objects and phenomena but they cannot be employed to change these properties and phenomena.

Practical methods bring the pupils close to the object of comprehension. Practical methods envisage conducting experiments, observations and laboratory work. Experiment and observation as methods of teaching, are specially good for revealing scientifically a science concept e g., absorption of water by root, photosynthesis, physical and physiological phenomena.

Experiment if not utilized properly as a method of teaching can not help the pupils in comprehending a. scientific topic. For example; the comprehension of physiology is closely interwoven with the comprehension of the structure of organs, evolution, development of organism etc. as well as comprehension of chemistry is closely interwoven with the comprehension of the atom molecular theory and structure of matter.

When experiments constitute the basis of teaching in chemistry, physics and biology, the knowledge of pupils becomes concrete. School experiment is not only one of the most significant sources of acquiring knowledge and practical skills but also it enables pupils to get accustomed to controlling chemical reactions, physical phenomena and logical processes, and get convinced of the cognisability of natural phenomena.

There may be three kinds of school experiments:

(i) demonstration experiment (ii) laboratory experiment, conducted by pupils while teacher is introducing new material, (iii) laboratory work.

The fulfilment of all the experiments given in a syllabus is obligatory. The list of the experiments need not necessarily be divided into demonstration or laboratory experiment. This is up to the teacher to decide. That is why a demonstration experiment is included in practical methods of teaching.

The volume of practical work includes not only experiment done by pupils under teacher's instruction, but also experimental tasks (preparation and extraction of substances, identification of substances and proof of their composition). Wherever possible maximum attention should be paid to attach investigatory character to an experiment.

Demonstration experiment: Two main forms of demonstrations may be distinguished: an illustrative demonstration and a scientific research demonstration.

An illustrative demonstration is preceded by the theoretical introduction of problems of the lesson. The experiment that follows it usually illustrates the information. For example a chemical reaction, represents a practical proof of their correctness.

The peculiarity of the research form of demonstration lies in pupils getting at the lesson a concrete cognitive problem, to be solved on the basis of their own observations. First, the teacher himself or 1-2 pupils with the teacher's help prepare whatever is necessary for carrying out the experiment. Each pupil takes an active part in observation, examines the device of the apparatus, describes the properties of the given substances. The teacher controls the discussion, focuses pupils' attention on the experiment. It is very important that the teacher should train pupils to

pay attention to the conditions in which the experiment is carried out (heating, cooling etc). Singling out of many other phenomena is the essence of the experiment. Suppose, the teacher throws a piece of sodium on to water without instructing pupils, the only thing they see, will be a ball running on the surface of water. It amuses them, but most important in this case is the cause of the phenomenon and the reaction itself.

After completing an experiment, pupils with the help of their teacher analyse their own observations and draw their own conclusions: Whether there exists any link between substances and phenomena (heating, burning explosion etc.), whether there takes place any chemical reaction from the point of view of the atom-molecular theory, and at secondary school, from the point of view of ionic, electronic or structural theories, and finally work out the equation of the reaction. Thus pupils obtain the knowledge of chemical reaction by means of research form of chemical experiment, get interested in chemistry as science and get accustomed to logical thinking.

Demonstration experiment must be convincing, distinct and simple, but all this depends on the methods of carrying out experiment. In this respect the combination of word and action is of utmost significance. Suppose while explaining the action of acids on indicators, the teacher asserts that litmus is reddened by the action of acid, but instead of adding acid to litmus, adds litmus to acid. This wrong action in demonstration influences minds to a greater extent than the correct word. In this case pupils get a wrong idea and assert that the reddening of the acid is affected by litmus. It does not mean at all that the teacher against tradition must always add acid or alkali to indicator. But while introducing this material for the first time, the teacher must act like this.

It should be mentioned as well that the success of any experiment greatly depends on its duration. At middle school wherever possible experiments must not last long, as children are impatient to see the results of the experiment. At secondary school, experiments can be more complicated and of longer duration.

Laboratory Work

It is mostly carried out to complete each theme or part of the syllabus and is of great significance for repeating or drilling the introduced material to enrich pupils in new observations and habits of independent work.

There are also two ways of using laboratory work at school (i) illustrative, (ii) investigatory. In the first case a laboratory work proves or illustrates an already known idea, rules or laws. For example, the teacher says at the lesson of botany: let us observe that seeds contain water.

In the second case teacher says: let us find out what substances the seeds contain. Let us heat them. What is seen on the cooler parts of the test-tube walls?

Answer: drops of water

What do seeds contain? Answer: Water

Thus illustrative experiment only proves the introduced material, while the investigatory one leads to pupils' active participation in the study process. That is why such an experiment is to be preferred. Some suggested experiments

are given below:

1. Experiment: Evaporation of water from leaves.

(i) Control. Water with a film of oil on its surface.

(ii) Water without oil on its surface.

(iii) Water with oil on its surface and a twig with leaves.

Deduction. Water evaporates from leaves.

2. Experiment based on cutting off the root, (a) Control, the end of the root is preserved. (b) The end of the root is cut.

Deduction. Cutting off the end of the main root results in the development of lateral roots.

The results of the experiment should be recorded in the form of a sketch, collection, herbarium, diagram etc.

For another example from chemistry, treat some substances with water. Pupils come to a certain conclusion that some substances get well or poorly dissolved, others are not dissolved at all. The solubility of some substances increases much upon a rise in temperature while the solubility of others changes only slightly.

Normally laboratory work under the guidance of a teacher is carried out by small groups of 2-4 pupils conducting the same experiments. The teacher gives instructions on the aim of the laboratory work. While instructing, the teacher not only gives explanations but also makes drawings of apparatus demonstrating certain manipulations with them Sometimes the teacher puts a number of questions to pupils who after completing the laboratory work answers them.

Experiments which are more complicated are carried out in steps. For example, suppose the laboratory work is on the preparation of iron sulphide. In this experiment pupils get first convinced that mixing of sulphur with iron gives no results. Now teacher proposes that the mixture should be heated to see if a chemical reaction occurs. The first part of the laboratory work includes measuring sulphur (3.5 gm) and iron (2 gm), mixing the powders in a mortar or on a sheet of paper until uniform mass is got. When all the groups of pupils get the same uniform mass, teacher asks pupils to throw a pinch of it into a glass of water and then shakes up the glass to prove that the mass presents a mechanical mixture. Then teacher asks pupils to heat the mixture and to compare the original mixture with the product of the reaction going on in the test-tube. The teacher shows how to heat the mixture and also observe for the reaction. Then the flame is concentrated on the upper part of the mixture until the beginning of the reaction is marked (there is no need to explain the character of these phenomena). After that heating must be stopped and pupils watch the reaction going on in the test-tube. Now pupils start carrying out the experiment. They see a rapid reaction taking place, the test-tube gets red-hot and may even crack. The mass is allowed to cool. The teacher discusses the results of the experiment. The teacher may ask pupils in what way they succeeded in heating the mass red-hot on a spirit lamp. It is found that the mass gets red-hot spontaneously and that the reaction is accompanied by emission of heat. Sometimes pupils assert that sulphur and iron get burnt. To explain the phenomenon it is necessary to exa-

mine the product of the experiment and to compare it with the mixture originally taken. There is no need of cooling the substance. The teacher proposes that the bottom of the test-tube with the fused mass should be broken off into a mortar, cleared of the broken glasspieces, then part of it tested by magnet and another part mixed with water. Pupils now see that the chemical reaction has resulted in the formation of some new substance. Senior pupils require less detailed instructions.

After the experiment has been carried out, pupils should write immediately an account of it. The account should consist of a schematic drawing of the apparatus, observation and explanatory notes, answers to the questions given in the instruction and the conclusion. The account should be accurate, short and clear. The teacher systematically checks accounts, explains mistakes and displays the best specimen of accounts.

An analysis of the school experiments by the teacher can solve the task of the teacher. He will be able to combine verbal explanation and use of audio-visual methods with experimental work in training the pupils to get the right kind of knowledge.

The teacher will succeed in solving all the tasks of training in case he employs all the types of school experiment in combination with verbal explanation and visual methods of teaching.

Classroom Experiments

Experimental Demonstration on Momenta

ASOK SINHA, BINA GHOSE and
B. D. NAGCHAUDHURI

AN investigation into the law of conservation of momentum can be worked out on the principle of projectile motion. When a projectile moves in a parabolic path, the velocity of the projectile at any point in its path can be resolved into two components —horizontal and vertical. As particles projected from the same height with different horizontal velocities will take the same time to fall to the floor, the horizontal distances they cover on the floor after fall will be proportional to their horizontal velocities. The air resistance in this case is neglected It does not contribute substantial errors if the balls are made of steel. If one spherical ball moving with an initial velocity collides with another ball of equal mass and size at a height, then the momentum will be shared between the balls. Their horizontal velocities can be calculated from the horizontal distances they cover on the floor. Adding the values of these two velocities the initial velocity of the striking ball before collision can be calculated If M be the mass of a single ball, v_1 be the horizontal velocity of the striking ball, v_2 that of the target ball and V be the initial velocity of the striking ball then

$$Mv_1+Mv_2=MV \quad \text{or} \quad v_1+v_2=V$$

Now by changing the angle of collision between the balls, the values of v_1 and v_2 can also be changed. On measuring the values of v_1 and v_2, the initial velocity in each case can be calculated. If this initial velocity retains the same value in all such cases, this truth will justify the law of conservation of momentum.

The calculation can also be made by drawing the parallelogram with the horizontal velocity vectors of both the striking and target balls and the angle of collision. The diagonal of the parallelogram will represent the resultant velocity. On changing the angles of collision, the horizontal velocities will be changed but the value of the resultant velocity will be found to be the same always.

$$V^2=v_1^2+v_2^2+2v_1 v_2 \cos \theta$$

where θ is the angle of collision.

An experimental demonstration on momentum on the above principle is given in the PSSC Laboratory guide for physics. The apparatus designed in

our laboratory is a modified form of the above apparatus where the error due to friction is carefully eliminated. In P.S.S.C. experiment, the height of the target ball cannot be changed. The apparatus used in our laboratory consists of a metal plane, 10 cms in length with raised sides as shown in fig. I. The bottom surface is sufficiently

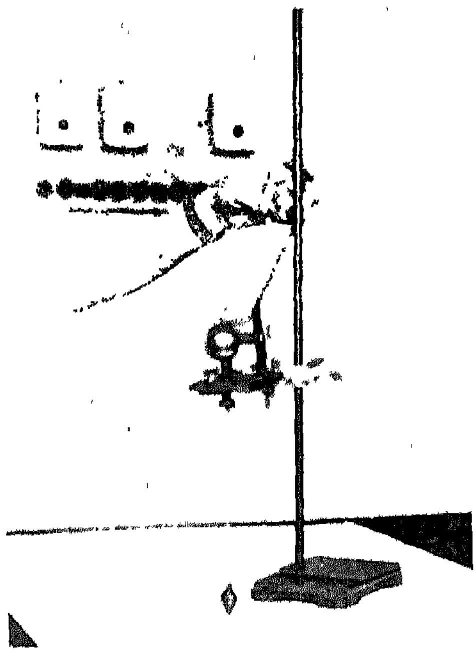

Fig. 1

polished to reduce friction. The plane is attached to a heavy base and proper arrangements are made to keep the plane at desired inclination. The plane with the base is then connected to a stand at a height of 25 to 30 cm. from the floor. The target ball rests on a screw the tapering end of which has been removed. The screw is kept in front of the inclined plane. The position of the screw can be altered in front of the inclined plane to change the angle of collision. There is also provision to change the vertical position of the screw. One plumb line hangs from the bottom of the screw to indicate the initial position of the target ball. In this apparatus the friction is reduced by using a polished metal plane. The height of the target ball from the floor can be changed and the velocity of the striking ball can be changed without disturbing the position of the target ball.

The apparatus is kept in a suitable place on the floor. Four carbon sheets are placed on the floor with carbon side up so that both the balls after collision will fall on the area covered by carbon papers. Now one large white paper, 60 cm. $\times$ 50 cm. is kept over the carbon papers. The target ball is placed on the screw and the position of the target ball on the white paper is noted from the tip of the plumb line. The striking ball having equal mass and same size is released from a height on the plane and both the balls will fall on the paper after collision. Positions of both the balls—striking and target are noted carefully from the dots marked on the other surface of the paper. The distance between two positions of the target ball will be proportional to its horizontal velocity. This distance is extended at the initial position of the target ball along the line by a length equal to the diameter of a single ball. The tip of this line indicates the position of the striking ball. This position is connected by a line to the final position of the striking ball and the angle between these two lines is the angle of collision. In Fig, 2, the angle of collision has been shown clearly. The vectors AB and CD represent horizontal

velocities of the striking and target balls respectively after collision.

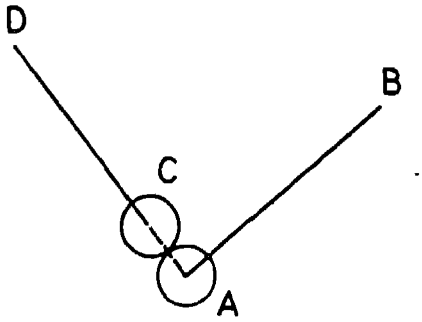

Fig. 2

The horizontal velocities of both the balls are added together in each observation and the sum of these two vectors is the same in each case as expected. This experiment can again be done by drawing a parallelogram. A parallelogram is now drawn with the vectors and the angle of collision as shown in Fig. 3. The resultant can be measured with a scale. On changing the angles of collision the values of the resultant can be measured in each case in the same way. If the value of the resultant comes out to be the same in

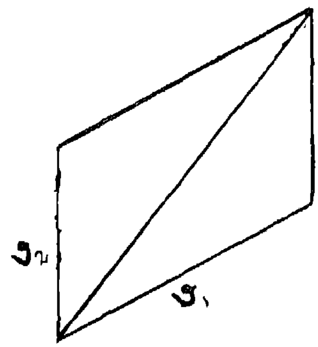

Fig. 3

all such observations it will prove that the law of conservation of momentum is substantially correct.

The results obtained by us in a series of experiments are given below:

Mass of single ball = 174 gm
Diameter of a single ball = 4.00 gm

NO OF OBS.	v_1	v_2	$U=v_1+v_2$	ANGLE OF COLLISION θ	V CALCULATED FROM THE PARALLELOGRAM
1	12.1	18	30.1	50°	27.4
2	13.2	18	31.2	48°	29
3	13.3	19 4	32.4	45°	30.2
4	12.4	18.4	30.8	50°	28.6
5	13.3	18.7	32.0	58°	28.3
6	11.2	18	29.2	39°	27.8
7	12 1	18 5	30 6	32°	29.4
8	11.2	19	30.2	7°	30.1

In the above observations the initial velocity of the striking ball before collision can be obtained by simply adding the two vectors and also from the diagonal of a parallelogram formed with the two velocity vectors and the angle of collision. Results obtained by the first method are within five per cent error. Errors may come in the measurement of angles in the second method due to which there are differences in the values obtained by the two methods.

This experiment can again be done by taking two unequal masses. Let M be the mass of a striking ball, m that of the target ball and v_1, v_2 be their respective velocities after collision. If V is the initial velocity of the striking ball before collision then

$$Mv_1 + mv_2 = MV$$

$$v_1 + \frac{m}{M} \cdot v_2 = V$$

On changing angles of collision as before, values of v_1 and v_2 can be changed but the value of V calculated from the above relation will be the same always. The length representing v_2 velocity of the target ball is extended at the position of the plumb line by a length equal to the sum of the radii of the two balls. The tip of this line is connected to the dot position of the striking ball and this length represents the velocity v_1 of the striking ball after collision.

We performed this experiment and obtained the results as shown below:

Mass of striking ball = 174 gm
Mass of target ball = 85 gm
Diameter of the striking ball = 4.00 gm
Diameter of the target ball = 2.9 cm

NO. OF OBS	ANGLE OF COLLISION	v_1	v_2	$V = v_1 + \frac{m}{M} \cdot v_2$
1	17°	16.8	17.3	25.24
2	23°	15.5	17.5	24.03
3	71°	15	17.3	23.44
4	48°	15.5	18.1	24.33
5	29°	16.1	14.2	23.02

The results obtained are within five per cent error. This experiment is an easy and simple method to demonstrate the law of conservation of momentum.

Some Experiments for Demonstrations of Low Pressure Phenomena

A. K. GUPTA and P. VIJENDRAN

THE need for developing the observational and experimental skill in students at an early stage of their career is obvious, particularly so if they chance to continue in the study of science. Hence the need for visual demonstration experiments to illustrate vividly the consequences of some natural laws. Our efforts have been directed mainly to experiments demonstrating low pressure phenomena, the detailed discription of which follows.–

The kit has been divided for convenience into two types (i) junior and (ii) the senior. This has been done to separate out the types of experiments that can be performed at pressures of 10^{-2} mm Hg (Torr) and above i.e. with a rotary pump alone and those that require pressure below 10^{-2} mm Hg, using a diffusion pumped system. Economy and ruggedness have been the main guiding factors in the design of the kits and the systems. Only indigenously and readily available materials have been used to enable its wide use.

The Junior Kit:

This basic system (fig. 1) consists of a bell jar mounted on a flange, evacuated by a rotary pump. Provision for mounting gauges, leak valves etc. exists. The base pressure attainable is in the region of 10^{-2} to 10^{-3} mm Hg. The following are the typical examples of the experiments that can be done with its help.

1. Study of mechanical force due to air pressure
2. Inflating of a sealed ballon
3. Air resistance
4. Buoyancy of air
5. Propagation of sound
6. Convection of heat
7. Conduction of heat
8. Mercury Manometer and Bourdon gauge
9. Torricellian method of producing vacuum
10. Vacuum filling
11. Combustion and lighting
12. Boling and pressure
13. Freezing by latent heat of evaporation
14. Discharge tube
15. Cloud formation by adiabatic expansion

The Senior Kit

This is basically a versatile combination system of a 11½" diffusion pump and a rotary pump with a manifold connector mounted on a trolley (fig. 2). The pressure is read by Bourdon,

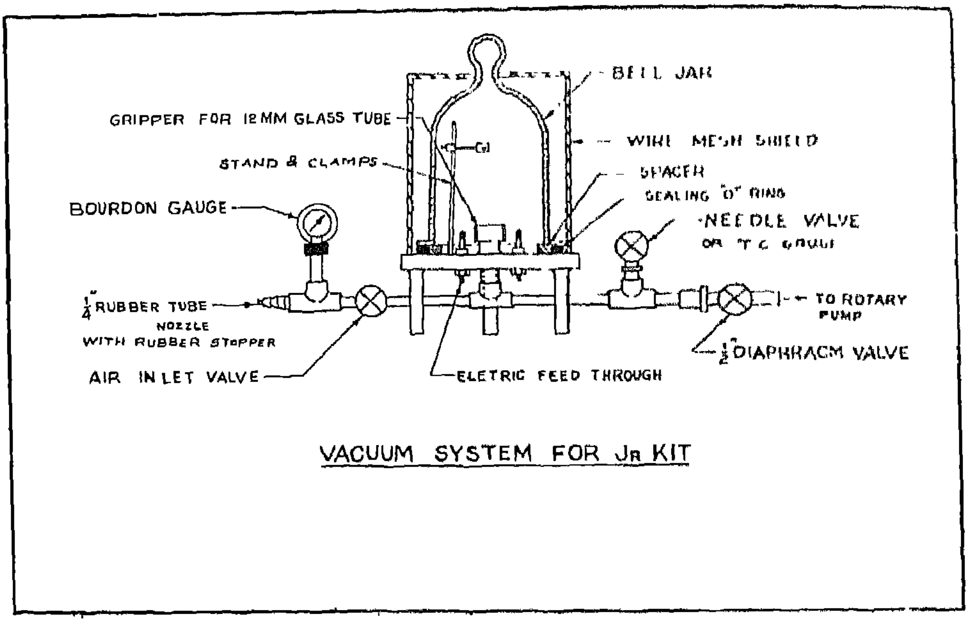

Fig. 1

thermocouple and cold cathode discharge gauges. The combined control unit for these gauges and the box containing the accessories for the experiments (which can be conducted with its help) are mounted on a trolley, (40″ x 31″ x 18″), which also takes the rotary pump in the bottom. The lay out of the plumbing and other components is very simple and illustrative and makes the experimenter familiar with the general vacuum techniques of plumbing and couplings.

The experiments above mentioned with the junior kit can also be performed with this set up and some of them can be studied in greater detail, like the discharge tube phenomena can be extended to the stage of black-out. Besides, the experiments demanding pressures of 10^{-4} to 10^{-5} mm Hg. and more sophistication can be performed. Following are the typical examples:

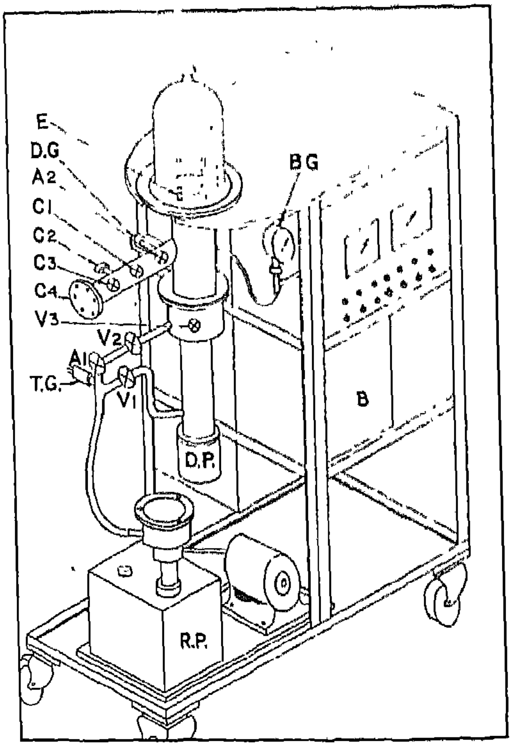

Fig. 2

1. Diode experiment
2. Boyles law and Mcleod gauge
3. Direct observation of molecular impacts.
4. Straight line motion of molecular beams
5. Vacuum deposition
6. Thermal conductivity gauges
7. Discharge gauges
8. Working of a rotary pump
9. Working of a diffusion pump
10. Study of other vacuum components.

Details of the Experiments of Junior Kit

1. Study of Mechanical Force Due to Air Pressure

It is an extension of the historic Von Guericke's experiment with Magdeburg's hemispheres. The whole design is changed to enable the quantitative study of the force required to detach two discs held together by atmospheric pressure and its dependence on the factors like sealing gasket diameter, the pressure difference and the volume of enclosed evacuated space. The quantitative understanding is important because of its close similarity with problems involving electric or magnetic flux across the surfaces of odd shapes.

2. Inflating of a Sealed Balloon

This vividly demonstrates, the pressure air exerts leading to the expansion of a balloon whose neck had been tied at atmospheric pressure with a little air in it, when subjected to decreasing pressure around it.

3. Air Resistance

This is demonstrated by subjecting a light feather to gravitational fall with and without air in a tube and comparing it with the fall of a metal piece.

4 Buoyance of Air

A sealed glass bulb is balanced on a light balance beam at atmospheric pressure and the change observed as the air around is evacuated.

5. Propagation of Sound

The fact that sound required a material medium for propagation is brought out by enclosing an electric bell in the bell jar and evacuating it. Care in mounting eleminates all contact vibrations

6. Convection of Heat

A thermometer hung over a hot surface indicates the need for gas (above a certain vacuum) for convective transfer of heat.

7. Conduction of Heat.

This demonstrates the effect of heat conduction by the gas molecules, from a heated filament and its dependence on pressure.

8. Mercury Manometer and Bourdon Gauge

This enables one to measure pressure in the classical way i.e. as mm Hg. and incidentally shows how this unit struck roots even to denote pressures as low as -10^{-10} mm Hg. (less than the diameter of Hg. molecule). The Bourdon gauge used also measures the pressures in the same range and can be calibrated against the Hg. Manometer. It is a typical example of the mechanical instruments of this class. The dial gauge used can be opened easily and the working appreciated.

9. Torricellian Method of Producing Vacuum

Illustrates how vacuum can be produced as was historically done for the first time in 1643. This enables one to

measure the saturated vapour pressure of volatile liquids.

10. Vacuum Filling

Demonstrates the ease with which a narrow inlet vessel can be filled with a fluid

11. Combustion and Lighting

This is to demonstrate need for vacuum in an electric lamp, besides throwing light on the use of tungsten filaments for various purposes in vacuum.

12. Boiling and Pressure

Boiling is an important natural phenomenon and is shown to be a state of a liquid at which its vapour pressure becomes equal to the total pressure on its free surface provided that this pressure is not very much less than 1 mm Hg whence the evaporation looses the violent characteristics of boiling.

13. Freezing by Latent Heat of Evaporation

Water kept in a watch glass at room temperature is rapidly evaporated by removing its vapours by evacuation. Then the loss of heat of evaporation is sufficient to freeze the remaining water in the dish. This process has found important application in "Freezedrying".

14. High Voltage Discharge in Gases

The standard discharge tube for the study of the nature of high voltage discharge with the nature and pressure of the gases is modified by providing two holes in the disc electrodes and letting the anode and the cathode rays strike fluorescene on the flourescent screens of the ends. Magnetic deflection of these spots tells about the nature of the charge of the particle beams.

15. Cloud Formation by Adiabatic Expansion

The cooling effect of adiabatic expansion of a gas is convincingly demonstrated by a cloud formation of the water contained in air on its sudden expansion into an evacuated belljar.

Details of the Experiments of Senior Kit

Diodide Experiment

A simple demountable, easy to assemble, electrode system facilitates the verification of basic laws concerning the thermionic emission. Its use as a diode enables the dependence of electron current on anode voltage, filament temperature and dimensions of the electrodes to be demonstrated.

2. Boyle's Law and Mcleod Gauge

A modified compact form of Mcleod gauge enables the student to verify Boyle's Law and use it as a pressure measuring device.

3. Direct Observation of Molecular Impacts

The momentum imparted to a mechanical system by molecular impacts can be studied with a simple apparatus. An ordinary glass slide is suspended vertically in vacuum by a suspension fibre with its opposite halves wetted with conc. $H_2 So_4$. When some water vapour is introduced, it is absorbed by the H_2SO_4 and momentum transfer is halved on these sides as compared to those at which the water molecules simply rebound. This difference in momenta transfer constitutes a torque and rotates the suspended system. Also, some simple-to-make designs representing important applications are suggested.

4. Straight Line Motion of Moleculer Beams

A molecular beam produces a very well defined image of an aperture in its path, which shows that molecules travel in straight lines. The inter-

molecular collisions of the residual gas molecules with the molecular beam can be demonstrated at higher pressures

5. Vacuum Deposition

This process has become quite a common technique in science and technology because of its immense usefulness. The system is capable of demonstrating the basic process. Coating of Magnesium on glass substrates is very simple and straight-forward giving a mirror finish.

Besides, the working principle and performance characteristics of the thermal conductivity gauge, rotary vane pump, oil diffusion pump and other components like diaphragm valves, vacuum couplings etc. forming part of the combination system can be studied conveniently with the help of the accessories.

A complete instruction manual with full design details of the vacuum systems and the accessories needed for the demonstrations named above can be supplied. The authors are thankful to the Head of Division Shri C. Ambasankaran for his keen interest in this development and his kind permission for publication. We also wish to thank the workshop and glass blowing people for their help in fabrication of the components.

The Refractive Index of a Liquid by Total Internal Reflection Within a Glass Prism

VED RATNA

IT is customary in the universities that students of Physics in undergraduate classes do this experiment. Principle of the method is briefly described below. This description has been summarized from that given by Worsnop and Flint[1]. Notation in the diagram has been slightly altered to suit the convenience of discussion which follows.

A glass prism ABC (figure 1) has the face AB ground. AB is illuminated by

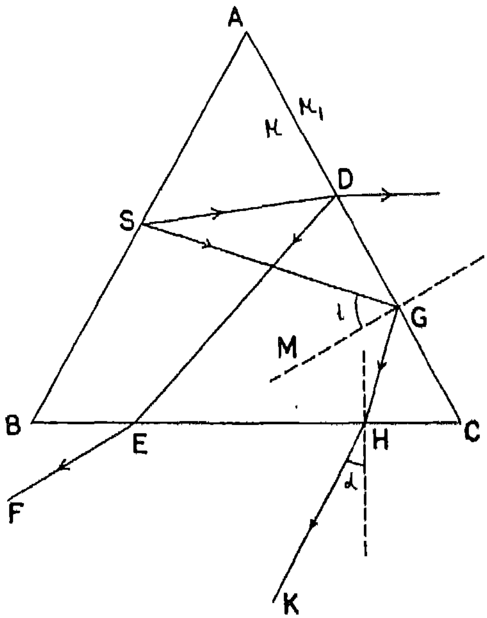

Fig. 1

monochromatic light. A group of rays parallel to SD reflects partially from the face AC, emerges parallel to EF and forms a line in the focal plane of a collimated telescope placed to receive them. Similarly a group of rays parallel to SG, where angle SGM is the critical angle of incidence i, is reflected totally, emerges parallel to HK and forms another line in the focal plane of the telescope.

All groups of rays whose angle of incidence is greater than i are totally reflected and others will be partially reflected. The effect will produce a field sharply divided into bright and dark halves by the direction HK, making an angle α with the normal to BC. The whole experiment is performed on a spectrometer and angle α is measured

If μ is the refractive index of the glass of the prism μ_1, that of the medium touching the face AC, and that of the medium touching the face BC is 1, then

$$\mu_1 = \operatorname{Sin} C\,(\mu^2 - \operatorname{Sin}^2 \alpha)^{1/2} - \operatorname{Cos} C \operatorname{Sin} \alpha$$

To find μ the liquid is removed from the face AC so that $\mu_1 = 1$, again α is measured and then

$$\mu^2 = \left(\frac{1 + \operatorname{Sin} \alpha \operatorname{Cos} C}{\operatorname{Sin} C}\right)^2 + \operatorname{Sin}^2 \alpha$$

Problem

For performing the experiment with the medium outside face AC as the given liquid, a thin film of the liquid is enclosed between the face AC and a glass plate LMNO (figure 2). A difficulty now arises as described below:

If i_a and i_l are the critical angles of the glass of the prism with respect to the media of refractive indices 1 and μ_1 respectively,

$$\operatorname{Sin} i_a = \frac{1}{\mu}$$

$$\text{And } \operatorname{Sin} i_l = \frac{\mu_1}{\mu}$$

Thus i_l is greater than i_a.

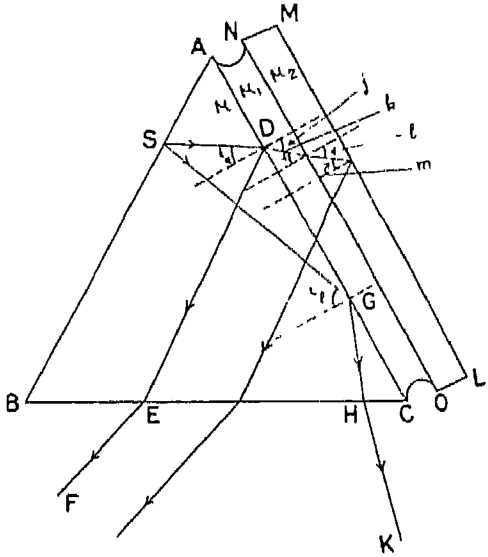

Fig. 2

While performing experiment with the liquid film outside face AC, a group of rays parallel to SD at an angle of incidence i_a is transmitted through faces AC and NO (after partial reflections). If we assume AC, NO and LM to be parallel to each other, then

$$\operatorname{Sin} i_a = \frac{1}{\mu}$$

$$\frac{\operatorname{Sin} j}{\operatorname{Sin} i_a} = \frac{\mu}{\mu_1},\ j = k,$$

$$\frac{\operatorname{Sin} l}{\operatorname{Sin} k} = \frac{\mu_1}{\mu_2},\ l = m$$

where the symbols have the meaning indicated in figure 2.

$$\therefore \operatorname{Sin} m = \frac{1}{\mu_2}$$

Hence m is the critical angle of the

medium of the plate LMNO with respect to the medium of refractive index 1.

Thus a group of rays parallel to SD is totally reflected from the face LM, emerges paralled to EF and comes to a focus in the same line in the field of view of the telescope in which the rays of this group partially reflected from AC get focussed Similar situation arises with any other group of rays whose angle of incidence on the face AC lies between i_a and i_l. Thus the field of view of the telescope is divided sharply not by the direction HK but by the direction EF.

Hence the value of α measured experimentally with the film of the given liquid comes out to be the same as that measured without it. Even if the liquid film and glass plate LMNO are not parallel-sided and the glass plate is not optically plane (which it really need not be), the value of α measured with the liquid film will be a little different. Of course, any difference so observed has no relevance to measurement of the refractive index of the liquid.

Solution of the Problem

To eliminate this difficulty, soot was desposited on the face LM. It was found that in this way the rays reaching the face LM are absorbed by it and dividing line in the field of view of the telescope corresponding to the direction HK (figure 3.) becomes prominent instead of that corresponding to the direction EF. Theoretically, soot deposited outside the face LM should not absorb the rays incident internally on it at an angle greater than critical angle. But perhaps, along with soot, a thin oil film gets deposited on the face LM and the trick works. Let us call this method as 'solution 1'.

The author is of the opinion that a still better method will be to stick a thin black paper on the face AC with the given liquid, instead of the ulate LMNO. But this can be done provided a paper of such a qua-

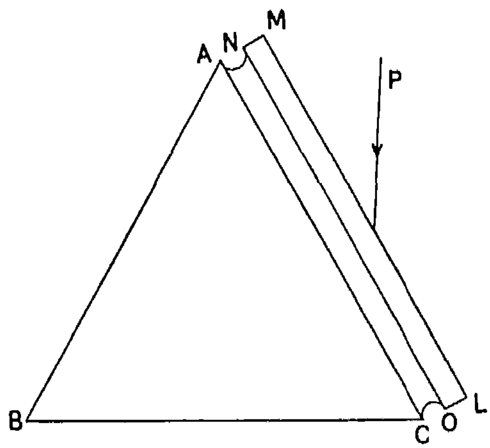

Fig. 3

lity is available which will not introduce impurities in the liquid film. This method will eliminate the possibility of interference finges being formed by the thin liquid film.

Worsnop and Flint[1], although do not talk of this difficulty at all, but give an optional precaution, which we shall call 'solution 2'.

> "It is better for the sake of defin'tion of the two halves of the field to allow light to fall at grazing incidence on the prism surface, say, AC (figure 1). Then the rays entering the prism make angles less than critical angle with the normal so that the field is now only half illuminated and the edge corresponds to the d'rection, HK (figure 1). AB should be kept

dark by covering with a sheet of dark paper".

"If the light is incident externally on the liquir film, it must enter by the edge, NM (figure 3), any ray such as P would not reach AC at grazing incidence."

Discussion

The 'solution 2' really refers to improvement of definition of the two halves of the field of view over what we get without the liquid film by the method of illuminating the ground face AB. The question here is of 'existence of any definition of the two halves of the field of view in the direction, HK (figure 2) when working with the liquid film'. It is true that if 'solution 2' is made use of, this question would not arise at all. But after reading through the description given by Worsnop and Flint[1] a student is likely to think that, when using the method of illuminating the ground face AB, some definition must exist Thus he may neglect the 'solution 2', obtain the same value of α in both the parts of the experiment and thus obtain a value I for the refractive index of the liquid.

From a purely educational standpoint, the 'solution 1' is better than 'solution 2'. When the student will adopt 'solution 1', he will see concrete before his eyes how does the intensity of internally reflected rays varies with their angles of incidence.

Indu Prakash and Ram Krishna[3], while discussing a simplified form of Pulfrich Refractometer, describe the entire experiment in terms of light entering from liquid to glass at grazing incidence. Worsnop and Flint[2] also do the same while describing Pulfrich and Abbe refractometers. Thus 'solution 2' is the more commonly used experimental technique

Allen and Moore[4] do not at all mention this experiment or the Pulfrich or Abbe refractometers in the entire book written by them, and similarly do the authors of the books 5 and 6 mentioned in the bibliography.

Houstoun[7] gives the same treatment of the experiment as Worsnop and Flint[1] without clarifying how the rays which enter from glass to liquid can be prevented from being totally reflected back Middleton[8] gives a simplified experiment to measure critical angle by a glass block, similar to Pulfrich Refractometer, wherein he talks only of external incidence.

Conclusion

Although from an experimental point of view it is a faultless and usually adopted method that monochromatic light is allowed to fall at grazing incidence on the prism surface so that it enters glass making an angle with the normal equal to critical angle. But Worsnop and Flint's attempt to describe the experiment using internal reflection is admirable from an educational stand point. They made an omission in this method which they may have considered to be a minor one. 'Solution 1' described above is an attempt by the author to develop it into a really practicable method, keeping its essential spirit intact. It should now be possible that this experiment using internal reflection may be widely adopted by the universities.

Acknowledgement

The author is highly indebted to Dr. N. K Saha, Professor of Physics, University of Delhi and Mr. S K Nandi lecturer, Department of Physics, University of Delhi, to have allowed him to hold charge of the equipment for this experiment for an unusually long period (in the year 1948), and to have guided him in solving this problem

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N.B. *The author does not claim to have made an invention When Worsnop and Flint or Houstoun had described this experiment using internal reflection it is highly probable that they must have known this difficulty and its solution They simply did not mention it considering it to be a minor issue*

Science Abroad

Miniature Sets will Make Radar a Household Gadget

ROY HERBERT

TECHNOLOGICAL advance is a slow business. Few developments are truly revolutionary, and even when they are, they seldom make a striking difference to everyday life and things.

In the last 10 years, perhaps only the development of transistors has had such an effect. In the next 10 years, advanced work in electronics at Britain's Royal Radar Establishment at Malvern may make itself felt on a similar scale.

For, because of this work, miniature radar systems are now a practical proposition. All at once exciting prospects have opened up for such things as hand-held obstacle detectors, collision-dodging equipment for motor-cars, and tiny burglar alarms

Pinhead-size Source

The heart of these gadgets will be a radar source the size of a pinhead, and it is this tiny device, already in commercial production, that promises to bring a revolution in its wake.

Radar, of course, uses radio waves to measure the position of a target, its range and its speed. The radio waves transmitted are reflected back and the information is obtained from the time they take to return and the change in wavelength of the echoes. They must be of short wavelengths—about one centimetre—in order to 'see' efficiently, and therefore high frequencies are necessary.

Until now, sources of radio waves at such frequencies have been comparatively large, delicate and with a short working life, in spite of the advances in vacuum tube design since the early days of radar in the 1930s.

Transistors not Suitable

Almost all the jobs that vacuum tubes did have now been taken over by transistors, which are more reliable, last much longer, and do not need large power supplies. They are solid-state devices made of a crystal material through which the electrons move—not through space as in the old vacuum tubes.

But as transistors would not work at the frequencies necessary for radar, they were out of the question for this particular application. The work being done at Malvern has changed all that.

By Courtesy: British Information Services, New Delhi.

The scientists there have been exploiting a property, known as negative resistance, in a particular substance in crystal form, called gallium arsenide. Normally, the current flowing in a conductor of electricity is proportional to the voltage driving it. But negative resistance means that as the driving force behind moving electrons gets bigger, they are slowed down and less, not more, current flows It is possible to use this effect in gallium arsenide to produce high-frequency radar pulses, or microwaves.

In the crystal, a section called a domain-separate from the rest—is formed in which the voltage is very high. It forms at one end and travels along to the other, when it collapses Immediately another domain is formed and does the same thing. The domains sweep through the crystal at high speed, generating radio waves as they go; the frequency of the waves depends, more or less, on the distance the domains have to travel.

Pioneer Work

To get the frequencies needed for a high-resolution radar system—in other words, one that can distinguish small targets—the distance is measured in millionths of a metre. So the crystals are minute, little more than a layer deposited on something else for support and to make the necessary electrical connections.

In fact, the microwave sources are made by depositing the layer on its support—a different type of gallium arsenide crystal—and then cutting the structure made in this way into small pieces. Other components are added to make the device tunable over a wide range of frequencies. Even so, the whole tunable radar wave generator is only the size of a thimble

Powered by batteries and containing a transmitter, an aerial, a detector and other miniature electronic gear, a radar set can now be held in the hand like a torch. The possibilities of such systems are being considered, and it should not be long before experimental ones are being used in working conditions.

Variety of Uses

For example, it ought to be fairly easy to measure speeds of ships coming in to dock The bigger the ship the more important this is, for even at low speed bumping into docksides can cause serious damage. On the enormous tankers that are now coming into service, it may be possible to have members of the dock crew working portable radar speed meters fore-and-aft and passing the information to the bridge.

Radar meters of this type could have almost limitless application in navigation in harbour waters. In industry, the potential is just as big—knowledge of distances and speeds are important in using machinery, and the smallness and simplicity of a radar equipment for measuring them accurately will prove invaluable.

But possibly the most spectacular of the early uses for the tiny radar sets will be in cars. There is no reason to doubt that cars will eventually have radar mounted, perhaps on the roof and that their drivers will be warned of obstacles in good time to avoid crashes. Equipment such as this would be a tremendous asset in fog on motorways, for instance.

Problem Simplified

The idea of using radar for this purpose has been mooted before. But equipment then was too big, too fragile, too expensive, and needed too much power. All these objections have been removed at one stroke by the new device.

Of course, in conventional radar itself there will also be advantages to be reaped. One of the troubles in radar operation is the necessity for moving large aerials to swing the radio beam, and recent systems have been designed to get over this by producing a scanning beam electronically.

The new microwave source simplifies the problem of doing this, as it will have other problems in improving radar systems.

This, however, will be a backroom matter. For the man in the street, the new development is likely to show itself in a great variety of devices for use in daily life—in his own home, his job, and in transport of different kinds.

As the radar systems are refined, new applications will keep step until, perhaps, radar-using gadgets will be as familiar as electrical ones are now.

Success of Hyperbarics in Modern Medicine

PAUL VAUGHAN

EXPERIMENTS with a form of medical treatment that promises to make a substantial contribution to the fight against disease are going on in a number of countries.

The treatment, which has been described as one of the major developments in medicine of the last five years, is known as hyperbaric medicine or, more simply, hyperbarics It involves bringing oxygen to the site of the disease and saturating the diseased tissues with the gas at a pressure two to three times the normal rate.

Successes

To give just a few examples of its successes.

A patient crippled for 40 years with osteomyelitis (a severe bone disease) whose sore limb healed and who could walk again unaided,

A man of 53 with a chronic ear discharge since a mastoid operation at the age of eight, whose symptoms suddenly stopped for the first time in 45 years,

Thirteen patients seriously ill with emphysema (extensive lung damage) who found they could breathe freely again.

Experimental work on the uses of hyperbaric medicine is going on intensively in many centres in Europe and North America. Britain has been, and is, one of leaders in the field, not only in the basic research but in the development of the sophisticated equipment which hyperbarics demands.

This includes pressure chambers, for if gas is used at high pressure the containers must withstand the force with which the gas will attempt to escape. And the chambers used in hyperbaric medicine must be big enough to take not only one patient, but the patient's attendants as well.

Years Ago

As long as 300 years ago, an English doctor called Henshaw experimented with a pressure chamber in which he hoped to cure acute disease with high-pressure air. What Henshaw began was taken up intermittently later on.

Scientists in the 19th century devised pressure chambers with elaborately elegant Victorian decors like a Jules Verne submarine But in the nineties the English Scientist J. S. Haldane put forward the fundamental ideas which led to the

Courtesy British Information Services, New Delhi.

present developments in hyperbarics.

Haldane showed that if mice were exposed to carbon monoxide gas, they died because the gas combined with the haemoglobin of the blood—the substance which produces the blood's red colour and which carries oxygen to the body's tissues. The mice died because they were starved of oxygen. But if they were put into oxygen at three times the normal pressure (at three atmospheres, that is) the mice survived.

Oxygen and X-rays

It was still more than 50 years before this work was followed up. But one of the earliest modern developments came when it was shown that this use of extra oxygen could have an effect on cancer. Scientists found that if the cells in a tumour were short of oxygen, they resisted the effect of X-ray therapy. So it seemed that if one could step up the supply of oxygen to these cells their defence against X-rays would be weakened.

At St. Thomas's Hospital, London, one of Britain's best-known teaching hospitals, doctors began to treat cancer patients with radiotherapy, while the patients breathed oxygen at three to four atmospheres.

Treatment on these lines has now become a standard practice at St. Thomas's and other teaching hospitals, and it has been found that the extra oxygen does indeed improve—sometimes dramatically—the effect of X-rays in certain types of tumour.

In Amsterdam, and a little later in Glasgow, doctors tried out the oxygen treatment when doing surgical operations on the heart. And in other centres more and more attention was being paid to hyperbarics and its implications.

A variety of medical conditions are marked by a local shortage of oxygen—due, for example, to injury or to diseased blood vessels. Wherever lack of oxygen was shown to be a complicating factor, it seemed likely that hyperbarics might help.

Beneficial Results

Although, this is still a relatively new branch of medicine, it has already been applied successfully to diseases of the bone, the joints, the lungs and the heart. It has been strikingly beneficial in treating gas gangrene, a grave condition which can follow serious accidental injury and is caused by a germ which does not like oxygen.

Pressure chambers used in hyperbarics are either very large or small enough for one person. One, recently installed at Glasgow's Western Infirmary, has an inside shell of 15 feet by 18 feet. It can take two patients at once, plus the surgical team, and will be used for heart surgery.

One Glasgow doctor has experimented with a miniature pressure chamber: it is 30 inches long but it is for mice, not men. For human patients there are hyperbaric beds in which the patient can be nursed for long periods in a highly oxygenated environment. In these, the patient lies under a Perspex dome and is completely encased in the bed. He keeps in touch with the outside world by an "intercom" and can watch television or listen to the radio, while the heat and humidity of the bed can be controlled automatically.

Still a Mystery

Ironically perhaps, scientists still cannot be sure why hyper-oxygenation

should be so beneficial in, for instance, diseases caused by germs. Does the oxygen act on the germs themselves in some way, or on the poisons which those germs produce?

At a recent international conference on the subject, one London doctor summed it up: "All we can say is that somehow hyperbaric oxygenation allows natural reparative processes to take place."

There are many other questions still to be answered about this new role for oxygen in medicine. It is likely that more applications of hyperbarics will be discovered. It is also possible that in the research now being done, in Britain and elsewhere, fresh light will be thrown on that ultimate mystery of medicine—the fundamental growth mechanisms of the human cell.

Young Folks Corner

Forty Years of Television

Anniversary of Baird's Invention Celebrated

DOUGLAS REEKIE

LONDON has just celebrated the 40th anniversary of one of the most far-reaching inventions of all time—the first public demonstration of television—by a dinner given by the Television Society

It was in January 1926 that John Logie Baird, a Scot living in the South of England, demonstrated his brain-child in London to the Royal Institution. A few days before, I had been one of a dozen or so people who had seen what he could do in sending pictures by radio. We had gathered in a house in North London. The demonstration took the form of a picture of someone in an upstairs room being shown to us downstairs in another room. The cynicism of the newspaper reporter made me disbelieve completely and utterly. I searched for hidden wires. They could not be found.

A Miracle

Finally convinced that I had seen a miracle performed, I wrote a story and then had to argue Baird's case with my office, which shared my own original disbelief.

To-day I look at television quite a lot along with more than 80 per cent of the people of Britain. I still think it a miracle, even though I get irritable and angry if there is the slightest fault in the transmission or in my reception.

To the celebration dinner in London this January went the first man ever to be televised—William Taynton, then an 18-year-old office boy and now a clerical worker in London. At the time of his historic first appearance on a television screen, he was working for a company which hired out cinema films from a building in Soho, London.

Attic Workrooms

Baird had his workrooms in the attic of the building. One afternon he rushed downstairs and asked Taynton for help. Upstairs in the attic, Baird set him under two rows of hot and bright lights and in front of a camera which he called a transmitter.

Taynton says that he barely had time to settle himself in his seat before a wildly excited Baird shouted at him "I've done it. I've done it" and seemed to dance round the attic.

A few moments later Baird pushed Taynton from his seat and took his place. Taynton went round to the other side of the transmitter. "I could just see the outline of Baird's face on the screen," says Taynton. "It was very indistinct, But I could definitely see a face." Just as I was to see a face on that screen in North London later, and the members of Britain's Royal Institution were to see a face in January 1926.

First Regular Programme

It was not until 1936, however, that the first regular public television service in the world started, when the British Broadcasting Corporation went on the air with a regular programme for viewers. In the ten years that had elapsed, considerable development of the techniques, Baird had devised took place. Once Baird had shown that television was possible, others stepped in with specialized knowledge that began to build towards the efficiency of the sets we know today.

World War II was to intervene before Britain could really exploit the new means of mass communication with full, countrywide coverage. (The BBC service was shut down from 1939 to 1946.)

In 1955, commercial television was introduced in Britain when Independent Television began operations. The BBC got its second channel in 1964.

Today, both Independent and BBC Television claim to have almost complete coverage of Britain. The BBC is linked with most of the European services and exchanges programmes with them. A few years ago television programmes were also being exchanged across the Atlantic with America through the Telstar satellite.

Television Personality

I do not think Baird, when he fetched Taynton in to be the first personality to be televised, ever thought or imagined that in 40 years his invention would have swept the world as it has done. Nor did he or Taynton for that matter —imagine that Taynton was to be the first of a whole new race of people. . the television personality.

But he was And, before the anniversary celebration arranged by the Television Society of London, he was shown in a studio the modern equipment used in television broadcasting. It was a little different, he thought, to the conglomeration of wires and gadgets Baird had taken him to see in that attic.

But then Mrs. Baird, who was also present at the celebration, rather thought the same. She remembered the oddments of wires and bits and pieces her late husband used to clutter up her home with.

Courtesy: British Information Services.

Science Notes

New Process Keeps Fruit Fresh Longer

FRUITS stay fresh longer and resist mould infection better by a new technique of regulating the 'breathing' of their skins developed by a British scientist

Dr. Henry Hurst, managing director of a Cambridge timber-proofing company, has spent years on research into the structure of insect and plant skins to show that if the skin of fruit is stabilized by a simple chemical process the resistance to variations of temperature and humidity, mould infection and bruising is greatly increased.

The stabilizing agent is a colourless, tasteless liquid which is cheap to make, and application is a simple matter of bulk dipping in the warehouse.

Successful Tests

Successful tests have been carried out with lemons, grape-fruit, oranges, tangerines, bananas and other fruit. In these, Dr. Hurst has established that the rate of ripening and decay depends on the reaction of substances in the skin, and that if this 'breathing' can be slowed down the fruit will ripen more slowly, keep longer and be more resistant to temperature changes.

A ripe, stabilized banana, for example, can stay firm and edible for up to four days at 34°C., while an untreated one softens after 8 to 16 hours. In average room temperature, according to Dr. Hurst, a treated banana should stay firm about 10 times longer than normal.

Dr. Hurst claims that his treatment could be of great value as fruit can be stabilized at any stage—after harvest, during ripening, or before selling in containers.

Collecting Medical Data on Human Body

Britain's Medical Research Council has developed 'a socially acceptable monitoring instrument' designed to record medical information about ordinary

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Courtesy: British Information Services.

people as they go about their daily work.

The instrument, which is attached to the body, yields information about the physiology of the active worker, the housewife, or the sedentary desk-bound executive.

Mr. H. S. Wolff, of the Council's Hampstead (London) laboratory, said the new instrument would record heart-beats and temperature for periods of a few hours or two or three days while a person went about his normal work. It would record information about ordinary persons in the same way as was done, for example, in the case of astronauts.

Electrochemical Cell

The device is a tiny electrochemical cell which enables doctors to detect a multiplicity of factors which contribute to a normal physiological environment. The same device can be used to help doctors assess how patients progress after treatment.

The device, connected to the body by two electrodes at the end of thin wires, is small enough to be worn without being noticed by anybody, and makes no noise. It has already been tried out on bus drivers and conductors, airline pilots, and schoolchildren.

Helium Bubble chamber at the Rutherford High Energy Laboratory

The helium bubble chamber that is being built for the Rutherford High Energy Laboratory at Chilton near Didcot, will be the biggest of its type. In common with bubble chambers using other liquids, it depends for its usefulness on the fact that a superheated liquid-one at a temperature higher than its boiling point at the pressure prevailing, but still liquid-boils locally, forming a line of bubbles, wherever a charged particle on its way through the chamber encounters an atom. It is, in a sense, the opposite of a wilson cloud chamber. Supercooling in a cloud chamber is brought about by a sudden increase in pressure; superheating in a bubble chamber by a sudden reduction in pressure.

Bubble chambers have two advantages over cloud chambers in high-energy research using beams of accelerated particles. The most obvious is that the density of atoms in a liquid is many times greater. Not only are tracks well defined; there is more chance of direct interactions with nuclei, leading to the formation of new particles in the chamber. The other advantage is that a bubble chamber requires only a few seconds' interval between one set of tracks and the next. It is unrivalled in its own field, though other methods complement it.

The choice of liquid depends on the type of experiment to the done. The Rutherford Laboratory will have three bubble chambers—each of different type —for use in conjunction with its biggest piece of equipment, the proton synchrotron, Nimrod, which accelerates protons to an energy of 7,000 MeV. Two of them require the use of exceptionally low temperatures. The first to be completed was the British National Hydrogen bubble chamber. This has been on loan until lately at the Geneva laboratories of the European Organization for Nuclear Research (Cern) but, after

reassembly next year, will be used at the Rutherford Laboratory. The advantage of hydrogen is that effectively only one type of nucleus is present—and that is the simplest proton. This is of help in interpretation when a particle interacts directly with a nucleus in the chamber and further secondary particles are produced.

The helium bubble chamber is well suited to the study of an odd kind of nucleus, known as a hypernucleus, in which the place of a neutron—present in all nuclei except hydrogen—is taken by an unstable and more massive particle, the lambda hyperon. Hypernuclei present many problems, in which the Oxford University Nuclear Physics Department is interested. The helium bubble chamber is a joint venture between the Oxford department and the laboratory.

The active region of the chamber will be 32 in. long$\times$16 in. wide$\times$17 in. deep. A powerful magnet will be used to bend the tracks of particles in the chamber, which is within the magnet. The biggest technical problems, however, have been in the refrigerator needed to maintain the helium in the bubble chamber at an accurately controlled temperature within a few degrees of absolute zero. Apart from control, it has been necessary that the final part of the refrigerator-including the vacuub chamber should be mobile. This is in order that it may be moved with the chamber to whatever position is wanted, and also can be removed when not in use. The refrigerator keeps the liquid helium in the bubble chamber at a controlled temperature in the range 3°k to 4°k within $\pm$0 05°k The third bubble chamber using a heavy liquid has just lately been brought into use.

Space Research Symposium

A NUMBER of distinguished scientists from India will attend an international symposium on space research to be held in London from July 17 to 29. Described as the biggest-ever conference on solar and terrestrial physics, it will be opened by Mr. Anthony Crosland, Britain's Secretary of State for Education and Science.

The sun has poured out its energy in the form of heat and light for millions of years and has made life possible on the earth; at the same time it sends out invisible ultra-violet rays and fast-moving particles, such as protons, which would be lethal to us if they were not stopped by the earth's atmosphere.

It is these phenomena, among others, that the scientists have been studying, and will discuss at the London symposium.

Some of the results of their studies will have practical applications. For instance, there will be considerable interest in the study of solar flares, which are huge outbursts of ionised gases which send particles millions of miles out into space, some reaching the earth. It is essential for the safety of astronauts and even the passengers and crew of high-flying supersonic aircraft like the Concord that scientists should know how to predict when these solar flares are going to take place so that avoiding action can be taken.

The scientists have been using the

latest aids available, including rockets and space probes.

The symposium will be attended by over 900 scientists from 45 countries They will assess the value of data obtained during the International Years of the Quiet Sun (IQSY) in 1964 and 1965. During the period intensive studies were made from ground stations and space satellites of the effects of the sun's radiation on the earth's atmosphere.

The London symposium has been arranged jointly by the Special Committee for IQSY and the Scientific Committee on Space Research (COSPAR). It is being held at the invitation of the Royal Society.

Indian scientists expected to attend the symposium include: Dr. Vikram Sarabhai, chairman of India's Atomic Energy Commission and of the Indian National Committee for Space Research; Dr. A. P. Mitra, National Physical Laboratory, New Delhi; Prof. P Ramachandra Rao, Andhra University; Dr. G. K. Setty, Delhi University, and Prof. P. D. Bhavsar, Dr. S. Prakash, Prof. K. S. Ramanathan, Dr. T. S. G. Sastry, and Dr P. R. Pisharoty (all five from the Physical Research Laboratory, Ahmedabad)

Fruit Fly Controlled by Lures

Both food and sex lures for the Queensland fruit fly, *Dacus Tryoni*, have been discovered and used to control the pest in the least 30 inland Australian towns. The method should also assist suppression efforts along the eastern seaboard where the fly exists in a more or less continuous population from north of Cairus to Victoria

Several State Departments of Agriculture have accepted the method as a preferable alternative to massive spraying campaigns using dangerous poisons such as DDT For almost a century the fly has been regarded as Australia's worst pest of orchard crops, but a recent conference of Federal and State entomologists declared that as a result of the improved control measures now available the fruit fly problem could be viewed as one of minor importance.

Mr A. Willison, an industrial chemist in Sydney, discovered the male lure some years ago. The attractant synthesised by him is 4-(p-hydroxyphenyl) butan-2-one. Subsequently research by Dr. Monro at the Waite Agricultural Research Institute, Adelaide, showed that the acetoxy derivative of this compound was even more attractive to the Queensland fruit fly. This form of the compound also attracts the melon fly, *Dacus Cuurbitae*, which is a pest in other parts of the world.

Meanwhile, American entomologists had found that certain protein hydrolysates are strongly attractive to the oriental fruit fly, and Mediterranean fruit fly. Tests by the New South Wales Department of Agricultural confirme that this material is also appreciated by the Queensland fruit fly. ICIANZ Ltd. in co-operation with the Department has since formulated a number of protein hydrolysates and selected the most effective for commercial production.

Though the sex lure has greater drawing power and is longer lasting it has not proved as effective as the food lure in field control experiments. However, when both lures have been distributed together suppression has been greatest.

Thus, in an experiment covering comparable areas where male lure and food lure were used separately fruit damage amounted to 20 per cent and 7 per cent respectively, but virtually no infested fruit was found in the areas in which the two lures were distributed. Malathion has been chosen as the insecticide to mix with the lures because it presents less risk to other animals and humans.

Courtesy: Australian High Commission, New Delhi

Problems in Mathematics

Students of secondary school and others are invited to submit solutions of the problems given below. Corrected solutions along with the names of those who solve these problems correctly, will be published in a subsequent issue of School Science. Only students, however, are eligible for the prizes that may be offered. Each problem should be solved on a separate sheet of paper and should bear the name of the student, his class and his school and should carry a declaration that he has solved the problem himself. Solutions should reach Shri R.C. Sharma, Reader Department of Science Education, NIE Buildings, Mehrauli Road, New Delhi 16, within six weeks of the publication of this issue. Readers are also invited to submit original problems along with their solutions.

Problems SS 31 to SS 35

J.N KAPUR and R.C. SHARMA

SS31 Draw the graph of:

$$y=|x-1|+|x-2|+|x-3|+|x-4|+|x-5|+|x-6|$$

and solve the equation:

$$|x-1|+|x-2|+|x-3|+|x-4|+|x-5|+|x-6|=9$$

Solve also the equation: $|x|+|x+\frac{1}{6}|+|x+\frac{2}{6}|+|x+\frac{3}{6}|+|x+\frac{4}{6}|+|x+\frac{5}{6}|=1$.

Generalise these problems and solve them.

SS32 (selected). Prove that the sum

$1^k+2^k+3^k+\ldots\ldots+n^k$,

where n is an arbitary positive integer and k is odd is divisible by $1+2+3+\ldots\ldots+n$.

SS33 (J.N. Kapur) Prove (without using calculus) that

(i) $\sin x_1+\sin x_2+\ldots+\sin x_n$ is maximum subject to $x_1+x_2+\ldots+x_n=\alpha$ when $x_1=x_2=\ldots=x_n=\alpha/n$

(ii) If $a+b=k$ where a and b are positive integers and k is a constant, then

$$(a+1/a)^2+(b+1/b)^2\geqslant 2(k/2+2/k)^2$$

SS34 (selected). Prove that there does not exist a natural number which, upon transfer of its initial digit to the end, is increased 2 or 4 or 5 or 6 or 7 or 8 or 9 times; but there exist natural numbers which are increased 3 times and find them.

SS35 (selected). Prove that if a and b are relatively prime natural numbers then

$$[a/b]+[2a/b]+[3a/b]+\ldots\ldots+[(b-a)a/b]=(a-1)(b-1)/2$$

New Trends in Science Education

Community Science Centre

K. B. SHAH

AT the School of Architecture at Ahmedabad a dozen advanced students have each taken on a new assignment; to design a building for erection in the near future to house a new science education and research facility. The Community Science Centre.

What is the Community Science Centre?

The Community Science Centre is an activity of the Nehru Foundation for Development for providing facilities and developing programmes for the understanding of science by students, teachers and the lay public and for the improvement of Science and Mathematics Education at all levels.

The idea was mooted three years ago by a small group headed by Dr. Vikram A. Sarabhai which began its preliminary work at the Physical Research Laboratory at Ahmedabad. The group began identifying institutions, teachers and students at Ahmedabad who were motivated by the same urge for introducing originality and creativity both among students and teachers. Keeping an open mind and uninhibited with any restrictive forces, the participants discussed the problems of science education, challenged hitherto unchallenged assumptions and came forward with new ideas. The group for the Improvement of Science Education, or GISE as it came to be called, met for regular interaction on a continuing basis to discuss specific problems and projects which could be implemented in the near future.

The GISE received financial support, grants and assistance from the National Council of Educational Research and Training, the Karmakshetra Educational Foundation, the Asia Foundation and from a number of local institutions at Ahmedabad.

As the scope of the GISE expanded, its activities from the Physical Research Laboratory were brought under the umbrella of the Nehru Foundation for Development, a vehicle for the consideration of broader question of social and educational nature founded by Dr. Vikram A. Sarabhai.

Experience gained in working together confirmed the Group's feelings that Science teaching in our existing educational system did not adequately provide either familiarization with the scientific method or the acquisition of knowledge through experimentation. The Group came to the conclusion that

if the understanding of science by students or by adults is to be promoted, what is needed is a facility where those who wish to teach and those who wish to learn can come and conduct basic experiments and be exposed through audio-visual and other means to the latest developments of science, science teaching and technology.

To fulfil such specific needs, the Group for Improvement of Science Education, with a financial grant from the Asia Foundation has created the Community Science Centre under the auspices of the Nehru Foundation for Development

Centre Programmes

In developing the concept and giving contours to the Community Science Centre, it must be understood that it will be built around two programmes—each independent at the start but moving towards each other and ultimately fusing to the advantage of both. The first programme is a continuation of one started three years ago—the GISE series. This is an effort by the teachers themselves through cooperative voluntary active participation to improve science teaching *content* and to spread and understand new ideas and approaches in science and mathematics by actually trying them out. It will continue as originally developed. The other programme will be a new one: conceived and planned by us with no restrictions set by existing academic traditions. Its purpose will be not to impart scientific information *per se*, but to illuminate the *process* of scientific thinking. These two streams flowing side by side will gradually blend one to the other and merge into a practical creative procedure eventually to be adopted we hope, into the formal school and college systems.

Stream I: Enrichment and Improvement Programme will encompass the following activites: (i) New Curriculum and materials development, (ii) In-service teacher's training through (a) week-end discussions, (b) refresher courses and (c) summer and winter institutions, and (iii) Gifted student programme.

Stream II, Experiments in Science Education in which the Centre will try stream out the following two approaches:

1. The Core Programme: In order to make science a living, meaningful experience for the Science Centre participants, the local scene and life patterns must be the backdrop, as Dr. Sarabhai has aptly put it, against which the drama of science is presented and understood. All levels of participants—elementary, secondary and college students, as well as teachers and the lay public, will find within the Core Programme, interests, degrees of complexity and refinement, at whatever quantitative and/or qualitative levels that will fit their needs and abilities.

In the Core Programme the elementary levels will deal with basics—they will come to understand how to: (i) pose relevant questions, (ii) select a workable hypothesis, (iii) search for proof, (iv) uncover new relationships, and (v) adhere to ethical standards and values.

For higher levels of sophistication these same fundamentals be refined. They will be translated into: (i) project design, (ii) collection of data, (iii) assessment of data (iv) classification and (v) measurement.

For the highest levels the same basic

concepts become: (i) description of experience, (ii) creation of experience and (iii) the understanding of experience.

II. *Audio-Visual Programme*: One of the most important features of the Community Science Centre will be the emphasis and inclusion in the Centre of adequate facilities for the participant to prepare and produce audio-visual content material, such as slides, films and tapes, himself. This material may be a record of an experiment, a demonstration of a procedure, a documentation of field trip.

Other Activities

(i) An ongoing activity of the Centre will be the accumulation, evaluation and communication of all material being developed by other agencies here and abroad. Paralleling this will also be the development of material of like nature by the Centre staff.

(ii) *Publication*: The Centre will publish Teacher's manuals and resource material for existing syllabi and also for the new programmes developing at the Centre. A newsletter on Centre activities will also be published.

(iii) *Activities for the Laymen*: Periodic lectures, demonstrations, film shows, science exhibits will be arranged for the lay public. The interested persons will also be invited to use the facilities of the Centre and participate in ongoing activities of the Centre.

(iv) *Seminars*: The Centre will organise seminars on regional, national and international level to discuss new problems of science education. These will also serve as a medium for exchange of experience and information.

Facilities

Facilities and service offered by the Centre:

(i) *Library*: The Centre shall establish a library of scientific books, films and film strips as well as journals of educational and popular interest.

(ii) *Science Museum*: We hope to set up a modest science museum including science exhibits developed at the Centre or received from outside.

(iii) *Workshop Facilities*: The Centre will have its own small but up-to-date workshop, staffed for the development of science exhibits, models and prototypes. In free hours and by prior arrangement our workshop facilities will be made available to outside institutions and individuals.

(iv) *Laboratories*: At the Centre the four laboratories, one each for Physics, Chemistry, Biology and Mathematics will each contain facilities to accommodate up to 25 participants at a time. These laboratories will be available on a shared basis to outside institutions. The zoo, aquarium, green-house and observatory maintained by the Centre for Study purposes will also be available for visits by outside groups.

(v) *Consultation*: The Centre can offer consultation services to outside institutions in the application of new methods of teaching and advise them in the development of their laboratories and libraries.

(vi) *National and International Exchange Programme*: It is one of our cherished objectives to set up a national and international exchange of experiences and relationships between our Centre participants and those of analogous groups in other countries.

News and Notes

1. THE EXPERIMENTAL PROJECT

All the trial editions of text materials in Science and Mathematics for class VII have been printed and distributed to 31 Experimental Schools. The revision of the trial edition of class VII materials has also been taken up. The revised manuscripts for text materials in Physics and Biology (both English and Hindi version) for class VII were completed and sent for printing to the Publication Unit. Work also continued on preparing the trial edition of Class VIII text materials which will be required for use in the experimental schools from July 1968.

A number of States were contacted and the new text materials developed under this project were made available to the State Education authorities for study to examine the possibility of using these materials in selected schools of their state.

2. THE UNESCO-UNICEF PROJECT

General Science syllabus for classes I to V has been published and is available from Publication Unit, B-31 Maharani Bagh, New Delhi-14 The first volume of the corresponding Teacher's Handbook—a three-volumes publication, is also out. Work is also in progress on writing the General Science textbooks for classes III, IV and V. Preliminary designs of a science kit and a science chart for use in primary and elementary schools have been developed.

Discussions were held with the State Education Departments of Andhra Pradesh, Madras, Mysore and Kerala to work out a subsidiary plan-of-operations for introducing this scheme of strengthening the teaching of science as a compulsory subject. Five other states: Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, and Uttar Pradesh had been visited earlier in this connection.

3. THE CURRICULUM PROJECT

The Directors and permanent staff members of the Five Study Groups in Chemistry met at Sardar Vallabh Bhai Patel University, Anand (Gujarat) from 27th to 31st January 1968 and reviewed the complete text materials for the lower level course. They also discussed about the contents of the first five units of the senior high school course in Chemistry. The trial edition of the lower level course will be available for tryouts by April 1968.

The Biology Study Groups have finalised their materials for the three years of the first stage of secondary schools

and are currently involved in editing and giving last touches to the diagrams etc. to make the materials press-worthy. They held a long meeting in the month of December to do this task jointly.

The Physics Study Groups at Delhi and Calcutta met at Delhi for about a month to dovetail the materials prepared by them for the first year of the first stage of secondary schools. They are currently involved in editing the materials and making them pressworthy. The materials will be available for press by February 1968.

The Mathematics Study Groups met a number of times at Kanpur, Jadavpur and Jaipur to finalise the materials developed by them. They have constructed instructional materials for all the three years of the first stage of secondary schools.

4. NATIONAL SCIENCE TALENT SEARCH SCHEME

The National Science Talent Search Examination was held on 7th January 1968 in 326 centres all over the country Necessary arrangements to get the scripts evaluated are under way.

A school-wise study of the results of the NSTS examination 1967 for Delhi Schools and its co-relation with the results of the Higher Secondary Examination and All India Higher Secondary Examination has been completed.

The first meeting of the Advisory Committee of the National Science Talent Search Scheme was held on 23rd January, 1968 under the Chairmanship of Dr. D S. Kothari, Chairman, U.G.C. The Committee reviewed the work of the scheme and agreed that from the next examination the test papers should be available in all the regional languages. It also recommended the organising of mathematical olympiades and reserving of certain scholarships for gifted students in mathematics.

For the undergraduate awardees of the National Science Talent Search Scheme 16 Summer Schools are to be held during this summer.

5. THE INSTRUCTIONAL MATERIAL CENTRE

The Instructional Material Centre displayed text materials and the various pieces of equipment developed under the experimental project in an exhibition organised by the All India Science Teachers Association during its Annual Conference at Gauhati. The Instructional Material Centre Organised a lecture on teaching of Chemistry through tested overhead projections by Prof. H. Alyea of the Princeton University

Books for Your Science Library

Modern Elementary School Science—a recommended sequence. WILLARD J JACOBSON and HAROLD E. TANNENBAUM published by Bureau of Publications, Teachers College, Columbia University under the series Science Manpower Project Monographs.

Modern Elementary School Science is the final volume in the Science Manpower Project series which includes recommendation for Junior High School Science, and for Biology, Chemistry and Physics in the Senior High School. The purpose of this monograph is to indicate directions for strengthening the elementary school science—a subject that has grown so much in importance as to be regarded as the fourth R of elementary school instruction.

The authors propose a two-dimensional programme of science experiences for children. In the flexible dimension, the primary concern is 'with the interests and needs of children as expressed through their question and concerns'. In keeping with the flexible quality of the programme, the authors have laid down guidelines which are suggestive rather than prescriptive. The flexible dimension gives scope for individualization of instruction (through children's questions as basis for scientific investigation) and its integration with other subject areas.

The planned dimension of the science programme offers opportunities to explore the various areas of science. The planned dimension serves as a guide in the purchase of equipment, books etc., it provides the framework for the total programme.

The bulk of the book is the chapter three — An elementary school science programme running from 31 to p. 144. After describing the general plan of a two-sided approach (the flexible and the planned) to curriculum, the authors give on p. 43 a general scheme for elementary science instruction. Understandings are developed around six broad areas. (i) The earth on which we live (ii) Healthful living (iii) The earth in space (iv) Machines, materials and energy (v) The physical environment (vi) The biological environment. A gradewise breakup of topics from kindergarten to grade vi is also provided.

The discussion of each topic starts with a broad definition of the scope of the subject-area, and a number of very

useful suggestions for providing the appropriate science experiences. The suggestions for activities though not elaborate are quite practical.

The important generalizations of each subject-area are listed separately. This is followed by set of key-questions serving to stimulate interest and inquiry.

Chapter 4 deals with Administrative Organization, which is held to be very important in controlling the quality of experiences in science. Three schemes for organizing school science have been discussed. (i) the classroom teacher teaches science, (ii) an elementary science teacher teaches science (iii) the classroom teacher-science consultant team together develop the science programme. This last scheme is considered to be the best since it combines the advantages of both the previous methods. The familiarity of the class teacher with the child and the familiarity of the consultant with the subject are both put to best advantage under this scheme of organization.

Chapter 5 is on 'Materials and facilities'. The equipment and supply list is very ambitious and unpractical at least for all but a few of our primary schools. The primary school teacher has to select (or improvise) articles within his/her means.

Chapter 6 is on evaluation. It discusses ways that can be used to determine the relative effectiveness of the educational experience and to find ways for improving programme. Evaluation would help to strengthen the programme on the basis of past experience.

The title for the seventh and the last chapter is Elementary School Science for tomorrow. As was expected, the discussion is with reference to American conditions. Yet, it is instructive and inspiring to go through some portions of this chapter e.g., discussion of the suggested goals for pre-service education of elementary school teacher on pages 188-190.

The book would be extremely useful for teacher educators and curriculum planners in science. There are not many good books by Indian authors on this subject and this book will be a nice addition.

B. D. Atreya

From the Editors

ON this page which will from now on be a regular feature of *School Science* we intend to discuss with our readers contemporary and significant events in the world of science and science education and, even more important perhaps to us editors, the journal itself. We would also request our readers to write to us their views and comments on any issue or problem in science or science education that they wish to bring to the notice of fellow readers, or their suggestions regarding this journal. We shall be glad to publish such letters, subject of course to considerations of space.

This issue of *School Science* has come out very late. For this there are numerous reasons. But rather than attempt an explanation or apology, we would like to assure our readers that future issues will reach them much more punctually.

Despite its lateness, however, this number of *School Science* maintains the usual quality and variety in its contents. The coverage ranges from a novel classroom experiment in acceleration to a discussion of the relative roles played by heredity and environment in man. Bina Ghosh, Asok Sinha and B. D. Nag Chaudhuri of the Saha Institute of Nuclear Physics describe an apparatus used by them to demonstrate acceleration, and they have solved the most difficult problem in such experiments—the measurement of time. S. L. Tandon, in *Heredity and Environment in Man* offers a very revealing discussion of this fascinating subject. In the field of chemistry, Anthony Tucker's *Catalysis and Chemical Kinetics* leads us nearer to an understanding of the complexities of the catalytic process, which to this day are not fully clear although the term 'catalyst' was coined by Berzilius over 130 years ago. Of special interest to teachers would be the third article in the series by B. Sharan, which deals with the more important aspects of practical training in physics. Again, in *Place of Museums in Science Education*, V. S. Agarwal tells how museums can be utilized in teaching the biological sciences; he describes particularly, and in detail, how the topic 'Propagation' can be thus taught. In *An Experiment on Science Education* A. G. Bhattacharya of the East India Laboratory, Calcutta and A. K. Ghose of the Bose Institute, Calcutta, describe an experiment in teaching the topic 'Current Electricity' to students in the age-group 13-16 years. The most striking features of the experiment were that attendance was voluntary and the participants themselves devised experiments to test the various principles and laws that were studied.

In science, as indeed in the humanities, perhaps the highest honour and recognition of outstanding talent and work is the Nobel Prize, and in his

article *Science Nobel Laureates,* R. K. Datta gives a vivid account of the lives and work of the 1967 Nobel Prize winners in physics, chemistry and neuro-physiology.

As for science abroad, the focus in this issue of *School Science* is on biology teaching. One of the most important science education projects currently under way is the Nuffield Project in the U.K., and two articles in this issue describe the work being done on biology teaching in this project.

In India, perhaps the most significant project in science education is the Project for Improvement of Science Teaching in Schools being conducted by the National Council of Educational Research and Training. In our regular features *News and Notes,* readers will find an account of the further progress made in this project, and of its Summer Course for the science teachers of the experimental schools.

Finally, we carry the results of this year's National Science Talent Search Scheme examination. For our young student readers, this will perhaps be *the* most absorbing feature in this number.

Reorganization of Practical Training in Physics–III

B. SHARAN

Indian Institute of Technology
New Delhi

The former two papers (Sharan 1967a, 1967b) *considered the non-absoluteness of measurements and the various forms of averages. The present paper deals with the more important aspects of practical training. These include introduction of preparatory questions which help in finding optimum conditions and choosing one's own apparatus, determination of laws from graphs, analytical and practical methods of drawing the best straight line and tangents to a curve. The emphasis is more on discouraging the 'cookery book' system and to encourage the power of thinking through the most efficient use of the knowledge at one's command. A number of practical examples have been given to illustrate the viewpoint.*

IT is often complained that the students do not take interest in experiments. The reason is, they get the necessary material and never feel the necessity of thinking. For an effective performance, an experiment should be preceded by the following questions:

i) What is the main physical quantity to be determined?

ii) Can the main physical quantity be determined directly, or is it to be determined by measuring other quantities?

iii) What are the other quantities and what is the functional relationship between the main quantity and the other quantities?

iv) Which quantity needs to be measured with the highest precision? What is the order of accuracy desired?

v) What instruments and methods are available for measurement? What are their accuracies and which instrument will be most suited for the work?

For answering most of the above questions, the exact functional relationship between the various quantities must be known or determined by dimensional analysis. The quantity which needs to be measured with the highest precision is the one which is small in magnitude and has the highest power

in the formula. This is the most important quantity. There is no gain in measuring other variables with an accuracy better than the most important one!

Experience tells us that the students learn to appreciate the idea of accuracy only after solving a few problems on percentage error. A very simple problem is suggested below:

Problem: Let the true values of two quantities **a** and **b** be 10 and 5 respectively. Now, if the measured values of **a** and **b** are 10.1 (error 1%) and 5.5 (error 10%) respectively, what is the percentage of error in the product **ab**? Is it less than 1%? Is it less than 10% (error corresponding to the most inaccurately determined quantity)? If, the measurement of a is improved to 10.01, does it improve the error in the product?

The case may be similarly extended for a product or quotient obtained by multiplying or dividing one by two or more terms. In each case it turns out that *the minium error is greater than the error in the quantity least accurately determined.* It is proved much more easily by using *differential calculus.*

Determination of Optimum Conditions for Maximum Accuracy

When there are two or more variables to be measured, for best results, all of them should be measured with the same precision. Sometimes, there are interdependent variables in which one is inversely proportional to the other. For a two parameter case, the relationship becomes hyperbolic in form *i.e.*

$$xy = \text{constant}$$

Such a case is of special interest, because an attempt towards a better accuracy in one is offset by the corresponding dimunition in the second. Below are given some examples to illustrate the viewpoint.

1. Suppose, it is desired to measure a given value, say 10 ml of water with an accuracy of 1% by means of a glass jar. It is further assumed that we can determine the radius of the jar accurately to 1/10th of a millimetre by a vernier callipers and height of the water column to 1/10th of a centimetre by a metre scale. What should be the optimum diameter of the jar? It is clear that if we increase the diameter for better results, the height of the water column would go down and upset the effort for a better accuracy. A compromise value can be found as shown in Table I.

TABLE 1

Showing how the accuracy in h demands onr

r in cm	*% error in cm*	*h in cm*	*% error in h*	*Volume in ml*
0.1	10	100	0.1	10
1.0	1	10.0	1	10
2 0	5.5	0.5	4	10
5.0	0.2	0.4	2.5	10

The optimum radius of the jar is 1 cm for this case, and this gives the minimum error in the measurement of volume.

2. Similarly, in the surface tension experiment by the capillary rise method

Radius × Height of capillary= Constant. Accordingly, the size of the capillaries required for various liquids would be different.

3. In a Young's modulus experiment, the attempt to determine more accurately, the radius of a wire by increasing its diameter is nullified by a corresponding dimunition in the elongation.
4. In specific heat measurements, if one tries to increase the quantity of water in the calorimeter for a more precise measurement, it leads to greater uncertainty in the temperature—larger the mass of water, smaller is the rise of temperature.

These difficulties will have to be tolerated in the experiments where the aim is to study the variation of one quantity with respect to the other *e.g.* Boyle's law, image and object position experiments in optics, frequency *vs* wavelength measurements in sound etc.

To make sure that the students come prepared to the practical class, they may be given in advance, sheets of *preparatory questions* which they may be required to solve and submit just after their coming to the class. The questions may relate to:

i) meaning of the technical terms like least count, back lash etc.,
ii) purpose of the instrument and the functions of its various parts,
iii) errors invloved in the experiment,
iv) any practical difficulty which the teacher might have met while setting up the experiment,
v) orders of magnitudes involved in the quantities to be measured, which may help in the selection of the proper apparatus.

A set of a few typical questions on some selected experiments is given below:

Copper voltameter (for E.C.E. of copper): What do you mean by the term current carrying capacity of a conductor? What should be the resistance specification of a rheostat for drawing 1.2 ampere current from a 2 volt accumulator (about 1 ampere current is needed for electrolysis)?

Seebeck Effect: What should be the minium sensitivity of a galvanometer required for the experiment?

Thermal Expansion or Bending of Beams: What should we use, a galvanometer, voltmeter or an ammeter for detecting that the spherometer has just made a contact with the beam? Remember, that a metal beam has practically no resistance.

Surface Tension: What is the optimum size of the capillary required for measuring surface tension of water at 20°C?

Here, it is assumed that the students are already exposed to a wide variety of measuring instruments in various ranges, and have a sufficient knowledge about their precision. For example, least counts of vernier callipers, screw gauge, an ordinary galvanometer are of the orders of 0.1 mm, 0.01 mm and one micro-ampere respectively.

The students at this stage, may further be instructed about some of the

important precautions to be observed while carrying out various measurements *viz;*

i) As far as possible, the instrument should not disturb the state of object under which it is to be investigated.

ii) The instruments should be moved or operated with delicacy and not with Herculian hands.

iii) The balance point in a Metre Bridge or any other experiment should be approached from both the sides. A simple A.C. measurement of conductivity of an electrolyte by using a Post Office Box (Kohlrausch Bridge) should bring the point home (Smith 1959) The same is true about the image positions in any optical experiment. The mean of the two readings gives a more realistic value.

iv) In all electrical experiments, the connecting wires must be short. This point is overlooked in general as is to be witnessed in the use of long and thin flexible wires in Metre Bridge or Post Office Box experiment, by most of the students in majority of the practical laboratories.

v) In experiments, where the order of magnitudes of the quantities to be measured are not known in advance an approximate value should be obtained first. Rough focal length of a convex lens is immediately known, by focusing the rays from a bulb or sun on a piece of paper.

vi) The position of minimum deviation in a prism spectrometer may be first located by eyes and then by the telescope.

Graphs and Graphical Experiments

Graphical experiments concern with the variation of one quantity with respect to the other by keeping others constant. They have to pass through three stages, performance, plotting and evaluation before any conclusions can be drawn from them.

Performance: It is advisable to make an exploratory trial first for some values of x in the range to be investigated and draw a rough plot. It serves two purposes, firstly in fixing up the upper and the lower limits of y and secondly, in the selection of the portions of interest. The limits help in deciding whether or not the same meter can be used in the entire range.

The interesting portions are those where the curve takes a sudden turn and the slopes are steep, here a large number of closely spaced readings are required. In all graphical experiments, as a rule, the curve should be traced back i.e. the readings should be taken for x increasing as well as for x decreasing. This is firstly, to discover, if there is any hysteresis effect and secondly for averaging out the values. This is the reason why in the experiments like Young's modulus and modulus of rigidity the readings are taken when the load is increasing as well as when it is decreasing. In B–H curve (magnetic induction *vs* magnetic field), it is well known that the ascending and the descending portions of the curve are different. A similar effect is observed in the case of the thermal expansion of glass.

Plotting: After the desired number

of observations have been taken they should be immediately plotted. The obvious advantage of plotting is that the whole nature of variation flashes out at a glance which otherwise may not be apparent from the actual values of the variables. It allows to give weightage to more accurately determined reading. The obvious disadvantage is the accuracy lost in plotting. In plotting the following points should be taken care of:

i) there are reasonable number of points which made the graph valid. The quantities which can be measured more accurately than can be read on a graph are not plotted e.g. mass and time,

ii) the scale has been chosen properly, such that it neither magnifies nor diminishes the accuracy of measurements (if y is varying very rapidly say by factors of 10 for small changes in x then log y may be plotted against x, vapour pressure *vs* temperature is one such example),

iii) each point is encircled or crossed and is accompanied by a vertical bar which indicates the uncertainty in the position of the point,

For a purely pictorial representation and qualitative discussions, only psychological appeal should govern the choice of the scale. However, this does not apply to experiments where we are mostly concerned with precision.

iv) whether the curves should pass through the origin or not (sometimes it may be inconvenient to show the point (O,O) for it involves waste of paper or an awkward scale; in such cases origin is transferred to some convenient point);

v) the graph through the points is drawn in such a way that the points appear equally scattered on both sides of the curve and finally,

vi) the axes are marked clearly, the name of the quantity plotted (or its symbol) is given along with the axes scale is neatly written and if possible caption of the graph is given.

The procedure (v) is based on the assumptions that y is a continuous function of x and the errors are random i.e. the number of errors with the positive sign are as many as with the negative sign. Strictly speaking, the method of 'best fit' is applicable only to straight lines. For drawing the straight line it is better first to fix up the centroid (x,y), where x and y are the means of the x and y coordinates of all the plotted points. A straight line is now drawn through the centroid such that the rest of the points lie evenly distributed on both sides of the line.

If the curve is not a straight line, a flexible celluloid knitting needle may be used to draw the curve smoothly. If necessary, the curve may be divided into small portions and the knitting needle is fitted suitable to each portion. It is a good maxim to follow that the curve should always be drawn first lightly with a fine pencil so that erasing and redrawing is possible afterwards.

The smoothness of the curve may be tested by holding the paper so that the eye lies almost in the plane of the paper. On looking at the curve, along its length from this position of the eye, even small angularities become clearly visible and can be easily located. These angularities should then be smoothened and the process of retesting be continued until every part of the curve is satisfactory. If necessary, firm line with a sharp and hard pencil or in ink may now be drawn.

It may be remarked that the free hand method gives a smooth curve i.e. one with as few points of inflexion as possible. Further, the 'eye' method works well when there is a small number of points of fairly high precision. When there are a large number of points of low precision, the 'eye' method becomes uncertain and it is better to use analytical methods. The methods of least squares applicable to straight lines is discussed later in this section. For 'chi-square' tests etc. used for general curve fitting, standard texts may be consulted.

Sometimes, people also use French curves for curve fittings. However, their use is not to be recommended because they may give unreal shapes to the curve in its various parts.

There is a large number of plots, choice of a particular type is dictated by the purpose, which it is required to serve. Eight types of plots which are in general use are:

i) *pictorial:* which merely show the variation of one quantity with respect to the other,

ii) *linear:* which are used to get some definite quantitative information about the experiment,

iii) *log:* when y is varying very rapidly with x, (as in vapour pressure *vs.* temperature curve) it is preferable to plot log y against x,

iv) *polar:* for radial or directional distribution (e.g. radial variation of intensity round an electric lamp, magnetic and electric lamp, magnetic and ering of particles by a nucleus, shock waves around a centre of explosion),

v) *family of curves:* for showing the effects of a third variable e.g. isothermals in Boyle's law, characteristic curves of a triode valve,

vi) *contour:* for showing the constancy of a third variable in all the directions e.g. isobars, isogonic lines, isothermals of the globe, electron density maps in X-ray analysis,

vii) *alignment, ordinary intercept and correlation charts:* for showing the effects of many variables. For details and illustrations Rose (1942) and Spangenberg (1957) may be consulted.

viii) *test plots:* for verifying or magnifying departures from formulae which otherwise may not be apparent e.g. Pv *vs* P and Debye *vs* T plots in Boyle's law and specific heats of solids respectively.

Each graph has some features and each feature should reveal some physical property and therefore, they should be noted. Below are given some features whose knowledge is also essential

for the tracing of the curves:

(a) *General nature of the curve.*

It may be linear, quadratic (time of swing of a pendulum), cubic (sag of a loaded beam), hyperbolic (P *vs* V in Boyle's law) exponential (charging of a capacitor) symmetrical, periodic etc. It helps in guessing the equation to the curve and discovering the law existing between the related quantities.

(b) *The portions in which it is straight and especially parallel to one of the axes.*

That region in which, part of the curve remains say parallel to the axis of X, tells that y remains constant there. For example, magnetic field between a pair of coaxial coils of a Helmholt galvanometer remains constant.

(c) *Saturation*:

A slightly different form of (b) is the exponential curve. Here y stays *practically* constant over large values of x i.e. *y* does not change appreciably for various values of x beyond a certain value. The examples are charge and discharge of a capacitor, radioactive decay etc.

(d) *Turning Points:*

These are the points on the graph where the slope changes sign. These may give rise to maxima, minima, points of inflexion. For example, resonance corresponds to maxima in a frequency response curve, power delivered from a battery is maximum when the external resistance is equal to the angle of deviation plot point of inflexion occur in a Gaussian distribution and in a beam uniformly loaded through total internal resistance of the battery, one determines angle of minimum deviation from a angle of incidence *vs* out (Rose 1958), in the latter case it is also called point of contra-flexure.

(e) *Discontinuities or Abrupt Changes of Slopes:*

These indicate a large change in the value of one of the variables for a small variation of the other quantity. In Helmholtz galvanometer, there is a steep drop in the magnetic field outside the coils. Point transitions in specific heats and discontinuities in X-ray absorption edges are well known.

(f) *Intercepts along the axes:*

The point or points at which a curve intersects the axes help in deducing the form of the equation and the evaluation of some of its constants.

(g) *Points where the graph terminate:*

Angle of incidence *vs* angle of minimum deviation plot in a prism spectometer experiment may indicate the positions of total reflection.

Now, we take up the application of the various types of plots. A pictorial or natural plot can be used for one of the following purposes.

(i) *Interpolation*: i.e. determining the value of one of the quantities y for a particular value of the other quantity x e.g. from a boiler one can find from the consumption of coal *vs.* time curve, the hour of the day when the consumption of the coal is maximum. Some of the other similar applications are calibration curves drawn between the corresponding readings of a thermocouple and a standard thermometer, determination of density at any temperature from a density *versus* temperature plot, values of interplaner spacing from Gnomonic curves (d *vs.* Θ plot), structure factor in X-ray analysis from f *vs.* Sin plot, for a scaling up or down

by a constant factor the marks of students.

(ii) *Extrapolation*: It means finding the value of y for any such value of x which does not lie on the curve. In such cases, the curve beyond the drawn region is extended according to its visible trend. The examples are the determination of absolute zero from Charle's law and lattice constant a for the glancing angle O=O from, a *vs* Cos²) plot in X-rays.

(iii) *Cut-off*: Intensity *vs.* wavelength in X-rays and stopping potential *vs.* wavelength in the case of photoelectric effect yield, Duane Hunt limit and the threshold frequency respectively.

(iv) *Calculation of intercepts and slopes:* In a resistance *vs.* temperature curve

$$R = R_0 + a_1t + a_2t^2 + a_3t^3 \ldots$$

the intercept on the resistance axis gives directly R_0 and I/R_0 x slope the value of the temperature coefficient of resistance at a particular temperature A platinum resistance thermometer, or a torch bulb may be chosen for this purpose.

Datta (1962) has discussed the details of such a method in the case of thermal expansion measurements by X-rays. Similarly, the value of the intercept along the E-axis, slope at the minimum of an internal energy (E) *vs.* entropy (S) curves gives directly the value of the free energy (F=E–TS) and the transition temperature (Seitz 1940) for a particular phase.

It is difficult to determine slopes, especially at a point where the curvature is large e.g. time *vs.* galvanometer deflection in Stefan's constant (Worsnop and Flint 1960). It is usually easier to draw a normal at the desired point and then to construct the tangent at right angles to the normal. The normal may be located by mirror (Daish and Fender 1959) or by a piece of capillary tubing (Llowarch 1967).

(v) *Area under the curve:* For example areas under a hysteresis curve, e.m.f *vs* charge in a thermoelectric diagram, within an indicator cycle (pdv or f (x)dx in general give the value of the work done.

For finding out the area under any curve there are three methods, counting the number of squares, employing trapezoidal rule or simpson's rule. In both the latter methods, the area under curve is divided by equally spaced ordinates. According to the *trapezoidal rule*

$$\text{area} = \frac{h}{3}\ \text{y start} + 4y_2 + 2y_3 + \ldots\ldots y + \text{end})$$

Where h is the difference in x-coordinate between successive y-values. Here, except the first and the last terms, all the middle terms are multiplied by 2. *In Simpson's rule*

$$\text{area} = \frac{h}{3}\ (\text{y start} + 4y_2 + 2y_3 + \ldots\ldots 2y_7 + 4y_8 + \text{y and})$$

Here, first and last terms are multiplied by unity, while the intervening terms are multiplied by 4 and 2 *alternately,* finishing with a 4 because an odd number of terms is used.

For many quantitative evaluations, it may be desirable to reduce a curve to a linear form by a suitable introduction of new variables. The obvious advantages of a linear plot are ease in:

interpolation
extrapolation
determination of slope and
intercepts along the axes.

One chief disadvantage of reduction to lineaı form is that it suppresses many of the important features of the original plot. Some of the features which disappear in the case of a compound pendulum have been mentioned later.

It may be remarked that in many cases both types of plots are necessary for a complete understanding of a phenomenon. An excellent example is provided by the experiments on ionization and excitation potentials (Wehr and Richards 1960), where it is essential to use a linear plot for the former and a pictorial one for the latter.

The transformation to the linear foım can be discussed under two headings when the form of the function is known and when it is unknown. (i) Determination of the constants of an equation when the form of the equation is known:

(a) Consider the expression for a bar pendulum

$$T=\frac{2\quad l^2+k^2\quad \frac{1}{2}}{lg}$$

Where g and k are unknown. Squaring gives

$$T^2l=\frac{4^2}{g}\quad l^2+\frac{4\quad ^2\quad k^2}{g}$$

or $y=mx+b$

where $m=\frac{4\quad ^2}{g}$, $b=\frac{4\quad ^2\quad k^2}{g}$,

from which g and k (radius of gyration) both can be determined.

It may be noted that the linear plot corresponding to eq (2) conceals the following features of T *vs.* I plot:

1. there is a minimum in the time period at $l=k$.

2. symmetry i.e. periods are equal on either side of $l=+k$ and further that there are four points of equal periods, and thaL

3. Gıaph terminates for these two values of I which correspond to the distances of the ends of the bar pendulum from the C. G.

It has already been mentioned when there is a large number of points, each of low precision, the eye method becomes uncertain. A large number of straight lines, with slightly different slopes appear to be equally probable. If it is assumed that the errors are all random than the best fit is obtained by employing the method of least squares. The outline of the method is given below:

We have a set of observations (x_i, y_i) through which it is intended to fit a linear relation

$$y=mx+b$$

It is assumed that each y is equally reliable i.e. has the same statistical weight, each xi is precise and all the errors are only in y_i. Now, the best straight line is one for which the error is minimum. It is obvious that if the errors are random, sum of the errors in y i.e. y_i will always be zero, hence we try to minimise the sum of the squares of the errors. Writing:

$$y_i=y_i-(mx_i+b)$$

and $(y_i)^2=y^2_i+m^2x_i^2+b^2+2mx_ib$
$-2mx_iy_i-ey_ib$

We get, for the sum of the errors.

$$M=\ (y_i)^2=y^2+m^2\ x_i^2+b^2+2mb\ x_i$$
$$-2m\ x_iy_i-2b\ y_i$$

The condition for the minimum value of M with respect to m and b are

$$\frac{\partial M}{\partial m} = O \text{ and } \frac{\partial M}{\partial b} = O$$

The first condition gives

$2m \sum x_i^2 + 2b \sum x_i - 2 \sum (x_i y_i) = O$

The second

$2nb + 2m \sum x_i - 2 \sum y_i = O.$

The simultaneous equations yield the best values of m and b as

$$m = \frac{n \sum (x_i y_i) - \sum x_i \sum y_i}{n \sum x_i^2 - (\sum x_i)^2}$$

$$b = \frac{\sum x_i^2 \sum y_i - \sum x_i \sum (x_i y_i)}{n \sum x_i^2 - (\sum x_i)^2}$$

Standard deviations for m and b can be found in the usual way (Baird 1962). We once again emphasize that here, (x_i, y_i) is the i th observed value.

The method gives us the best averaged value of the constants and saves us from the botheration of finding the average value from a number of observations. For example, $(\text{period})^2$ *vs.* length curve of a simple pendulum can be used for finding the mean value of the acceleration due to gravity.

Firstly, it may be remarked that after all these steps, one should not expect an accuracy better than what the instruments can read. Secondly, reading of the slopes directly from the graph for 45° is not to be recommended, as 0 approaches 90°, a slight error in the reading leads to a great error in the value of the slope. For 0 45°, only analytical methods should be used.

(b) The thermionic current density emitted from filament is given by

$$J = AT^2 \exp\left(-\frac{O}{KT}\right)$$

Where A and O are unknown. Transforming it to the form In $\frac{J}{T^2}$

$$\ln\frac{J}{T^2} = \ln A - \frac{O}{k} \cdot \frac{1}{T}$$

or $y = b - mx$

where $y = \ln \frac{J}{T^2}$ and $m = -\frac{O}{K}$

A and O both can be determined.

(c) For a radio-active decay

$$N = N_o e^{-\lambda t}$$

$$\ln N = \ln N_o - \lambda t$$

$$\text{or} \quad y = b - \lambda x$$

gives both λ and No.

A similar plot will hold for *In* of intensity *vs.* thickness of the absorber for x-ray and γ-ray absorption experiments, *In* of number of disintegration *vs.* half life or mean life for cosmic rays, and *In* of energy *vs.* range for α-particles (Halliday, 1950 pp. 146, 452, 146).

(d) Log-log plots are very liberally used in Nuclear Physics and Cosmic Rays, e.g. in *In* cross section *vs.* *In* energy of the incident particles, *In* fission *vs.* *In* mass number, *In* meson emissivity *vs.* *In* momentum of incident cosmic rays (Halliday 1950 pp 226, 229, 232, 249, 408, 446).

Cases Involving Three Unknown Constants

Suppose function has one of the following forms:

1. (a) $y = bx^n + a$

   Some of its special forms are

   $y = ax + b$, $y = a + b/x$, $y = a + bx^2$, $y = ax^n$ and

   (b) $y = a(x + b)^n$

2. A quadratic or parabolic from

   $$y = a + bx + cx^2$$

3. $$y = a + be^{nx}$$

4. A periodic form

   $$y = e^{-ax} \operatorname{Sin}(bx + c)$$

All these equations involve the finding of the three constants a,b,c (or n). In some special cases one of the

con stants may be zero which will make the task easier. The following helps in arriving at the correct form of the equation and consequently the course of transformations to be adopted for the plot. Note the nature of the curve, see whether it is parabolic, periodic, monotonically increasing or decreasing or is symmetric. The first two should have the relationships of types 2 and 4 respectively. A montonically increasing or decreasing curve tells whether the exponent n is positive or negative and the symmetric nature decides that the powers are even. Now, the intercepts along the axis of y and x are seen, the former gives the value of the constant a in 1(a), 2 and 3 and the latter of b and c in 1 (b) and 4 respectively. If either of them is zero the curve would pass through the origin. The periodicity of the curve gives the value of b in 4 and consequently by choosing any point on the curve a can be determined. Similarly, any two points in 2 yield the values of b and c. Now, for deciding between 1(a), 1(b) and 3 the following transformations are made.

$\ln (y-a)=\ln b+n \ln x$ for 1(a),

$\ln (y-a) = \ln b+nx$ for 3.

Here a plot of $\ln (y-a)$ vs. $\ln x$ in the first, $\ln y$ vs. $\ln (x+a)$ in the second and $\ln (y-a)$ vs x in the third case would give a straight line and hence from the slopes and the intercepts the constants b and n are obtained.

A word of *warning* is necessary concerning the plotting of logarithmic values. The mantissa of a logarithm is always positive whereas its characteristic may be either positive or negative. The trouble is avoided by first marking the characteristics on the log axis of the graph and then putting the mantissa as always increasing from the negative to the positive direction.

$\overline{2}.0 \quad \overline{2}.5 \quad \overline{1}.0 \quad \overline{1}.5 \quad 0.5 \quad 1.0 \quad 1.5 \quad 2.0$

For a very general form of a curve special methods are needed. Some special general forms which can be treated conveniently are polynomial forms.

$y=a_0+a_1x+a_2x^2+ \ldots +a_mx^m$ and a periodic form $y(t)=y(T+t)$.

The examples of the former are equation of state of a gas in terms of the virial coefficients, variation of electrical resistance with temperature and of the latter are analysis of a wave (electrical accoustical or optical), vibration of strings, daily weather etc.

It is sufficient to say that m constants of a polynomial can be determined by solving m simultaneous equations. The m equations are set by putting the numerical values of x and y of m well chosen, widely distributed points of the curve. If the points chosen are very near they may yield the equation to a straight line. Similarly Fourier analysis is applied to periodic functions.

It may further be remarked that normally it is assumed that y is a continuous function of x and there may be infinite possibilities which may be fitted and made to pass through a finite number of points. In fact, the best thing for an investigator is to start from the simplest y=constant, or a straight line of zero slope and then to go over to the more complex parabolic, exponential and logarithmic forms.

In the conclusion it may be said that if it be possible to design an experiment in which all the variables except

the ones under investigation, are completely under control, then in principle, the above mentioned methods should help in determining the complete functional relationship between the different quantities.

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Heredity and Environment in Man

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BATESON in 1906 proposed the name 'genetics' for the science concerning heredity and variation. The words 'heredity' and 'variation' mean the resemblances and the differences, respectively, shown between the parents and their progeny. The fundamental principles of inheritance which operate in man are essentially the same as in other animals or plants. The study of the relative importance of heredity and environment in the development of human bodily traits and of intellectual and emotional faculties has been of great general interest. No final and generally convincing solution of this problem has as yet emerged. Traits such as alcoholism, criminality, poverty, nomadism or their opposites are frequently observed to recur in some families generation after generation and because of this are often ascribed to heredity. This conclusion need not necessarily follow because the facts can often be as well accounted by assuming that these traits are environmentally controlled. It is evident, for example, that a child growing up in a family in which criminal conduct is regarded with favour is more likely to fall into delinquency than a child in a family in which honesty is admired. Similarly, social eminence is more easily attained in families of wealth and refinement than in surroundings of poverty and ignorance.

The most important general restriction on the study of human genetics has been the constitution of our society so that we are not able to subject ourselves to rigorous experimental conditions. In experiments with other animals and plants, the environment is kept constant so that the effects of genetic differences alone are measured for each type of environment. The other experiment is planned in such a way that different genotypes are kept constant so that the effects of environmental differences alone can be studied. The term genotype is given to a group of individuals which show the same characters generation after generation. In other words, it is a distinct and a genetically stable form. In man, isogenic (genetically identical) strains are not available for such experiments. It is also not possible to control at will the environment in which the individuals would develop their characters. Nevertheless, certain phenomenon in man approaches the ideal arrangement of an experimental design.

Identical twins are isogenic and permit studies of the effects of different environments, while non-identical twins are genetically different and permit studies of the effects of different genotypes in a similar environment. The identical or the one-egg twins originate from the division and separation of a single fertilized egg. That is why these are also known as monozygotic twins. Members of such a pair are identical, as to genes in chromosomes, since the nuclei of their cells have arisen by mitosis from a single common source. Genes are heredity determining particles. The fraternal or the two-egg twins result from the fertilization of two different eggs by two different sperms. The members of such a twin pair are no closer genetic relatives than are sibs of different birth. Sibs are offspring of the same parents.

Photo I. The striking physical resemblance of the monozygotic twins can be clearly seen in this case.

A particularly simple way of scoring differences between twins is to consider such traits which are either present or absent. The twin pair is regarded as concordant when both the members possess or do not possess a particular trait. Discordance in this context would thus mean that only one of the members of the twin possesses the trait and the other does not.

The strikingly greater physical similarity between identical twins than between fraternals indicates that this resemblance is due to their identical genes rather than to similar environments which fraternals also share within their mother's body. Identicals are always alike in sex, blood groups, hair and eye colour and many other physical traits, while fraternals may differ in any one of them. This is, in fact, a good evidence that heredity is the deciding factor in respect to these traits. Even more significant are observations on identical twins who have been separated at an early age and brought up in different environments. Since identical twins reared apart retain their similarities in most physical traits, these features are considered to be relatively independent of the type of environmental influences encountered after birth. The similarity in the physical features of the two sisters or two brothers comprising an identical twin pair can be so perfect that even the parents of the twins may find it difficult to distinguish one from the other. It has been observed that the members of the identical twins show similarity even in such a character as the type of facial folds in the forehead. The skin colour is also similar in identical twins. It may, however, be mentioned that skin colour of an individual can be temporarily influenced to some degree by external surroundings. In most of the cases even the finger prints of the identical twins are similar to each other.

It has been found, in general, that pieces of skin taken from one person and grafted to another do not remain

Photo II. The non-identical nature of the twins is evident from physical dissimilarity of the two boys

healthy but slough off after a few days. This histo-incompatibility is due to the genetical dissimilarity in the tissue of the donor and the recipient. It has therefore become a common practice to use the skin of one part for grafting to another part of the same body. This type of skin grafting is successful as the genetical make-up of all the skin present in different parts of the same body is one and the same. Permanent and successful grafts can be obtained if the donor and the recipient are members of a monozygotic twin. Since identical twins have all genes in common, grafts from one twin to the other are accepted as are grafts from one part to another part of the same body. Tissue-grafts have been used in deciding the relationship between the two members of a twin who had been separated from each other and assigned wrong parentage by mistake. The skin grafting test was used to find out the correct parentage of a boy in Switzerland. Six years after the birth of a pair of clearly non-identical twins, Victor and Pierre, it was observed that another boy, Eric, of another family had a striking resemblance to Victor. The suspicion arose that a mistake had been made in the assignment of the babies as all the three children were born on the same day in the same hospital. It seemed likely, on the basis of the physical resemblances, that Eric was the identical twin of Victor and that Pierre was a single birth child belonging to the other family. This was proved correct by successful skin grafts from Victor to Eric and vice versa. The skin grafts from Victor to Pierre and vice versa did not succeed. The other circumstantial evidences also went in favour of the conclusion drawn on the basis or the results of the skin grafting test.

The power of heredity may express itself dramatically in identical twins, even though they have been brought up under different conditions. There is an interesting case in literature of a twenty-two year old farmer who refused to eat his lunch one day because he thought his mother was trying to kill him by poisoning the food. Gradually, he became more and more psychologically deranged. Finally, he was admitted to a mental hospital as a victim of a disease called schizophrenia. Two weeks later another person who had been living with his aunt at another place for the past five years was admitted to the same hospital suffering from the same disease. It turned out that he was the first patients' identical twin. It may be pointed out here that studies on twins from several countries uniformly show high degrees of concordance for schizophrenia in identical twins and lower degrees in non-identicals. The incidence of schizophrenia, a hereditary mental disease, in the general population has been estimated as approximately one per cent. The identical twins, in general, show

much more similarity with respect to their susceptibility to tuberculosis than the non-identicals. The high concordance may also be interpreted to mean that if one member of a given pair has tuberculosis, the other twin has a good chance of getting the disease. The fact that the disease does not always strike both the members of an identical twin may be considered as an indication of the fact that environment also plays an important role in the expression of this character. It has been reported that the tumors affect both members of a monozygotic twin pair far more frequently than they do the two members of a dizygotic twin pair. Further, the tumor was found to be of the same type and occurred in the same organ far more frequently in the identicals than the fraternals. The age of onset of the tumors was much more nearly similar in the monozygotic than in the dizygotic. These findings emphasize the role of heredity in tumor production and their age of onset. The role of environment in relation to tumor production would be almost the same as discussed with respect to tuberculosis. The studies on the general metabolic patterns of the identical twins have given some interesting results. In one of the investigations various individuals were tested for thirtyone physiological traits, which included taste sensitivity to different substances, the amounts of different substances in the saliva and the presence of some substances or the properties of the urine. Identical twins, in general, were found to be similar in their metabolic patterns. Two other physiological traits which have been studied in human twins are blood pressure and pulse rate. Concordance to the extent of 63 per cent has been recorded for the identical twins with respect to their blood pressure*. The high concordance could be due to genetic identity or to the similarity in the environmental conditions in which the twins grew up. The non-identicals showed 36 per cent concordance and 64 per cent discordance The genetic dissimilarity of the non-identicals may have contributed its share to the high discordance. The trend of observations about the pulse rate are also similar as the ones described for the blood pressure. The environment is, however, known to have a profound influence on such characters as blood pressure and pulse rate.

The studies on the criminal behaviour of the members of two types of twins have been of great interest. The high concordance of a criminal record in indentical twins may not be due to a bad home background alone since concordance in the non-identicals is comparatively much lower and non-identical twins also show a common home background. The studies on the life histories of the individual cases of some twins have disclosed that concordance in identical twins signifies not only that both were at one time or another in prison but that the type of crime was even quite similar. In many cases, both members of an identical twin became offenders at a time, after their common childhood, when they had no more contact with each other; and non-identical twins were often discordant even if closely associated with each other. The high concordance of identical twins for many traits which have been determined

*The concordance for blood pressure meant agreement of the twins within a pressure difference of 5 mm Hg.

to have hereditary basis may incline one to attribute the greater concordance in criminality of identicals as compared to non-identicals to the identity of their genotypes. The greater similarity in the environment of identical twins plays an important role in this trait of criminal behaviour. The facts on criminality in twins actually show only that identity in genes plus the close similarity in social experiences, at least in early childhood, are more likely to bring both identical twin into prison than two non-identicals who have non-identity of genes plus less similar social experiences. On the basis of the present data, one cannot exclude the possibility that the higher concordance for criminality of identical twins is mainly the result of their more social experiences; nor can one exclude the opposite possibility that their high concordance is mainly the result of their identical genotype. Studies on criminal twins who have been reared apart from birth may help in getting the correct answer to this question. It is, of course, quite doubtful that a behaviouristic trait like criminality should be regarded heritable as often the economic conditions can lead one to committ a crime.

It is comparatively difficult to determine the relationship between heredity and environment with respect to intelligence and other mental and emotional traits. The identical twins reared apart are often quite appreciably different in such triats, although still somewhatless so than is the case with the fraternal twins. Psychological traits seem to be, accordingly, more susceptible to environmental modifications than are physical traits. Interesting observations have been made on the heredity-environment relationship with respect to intelligence. This is a character which is based on the assumption of inherited psychological capacities and acquisition of external cultural tools. One of the methods to find out the intelligence of a person is by determining the Intelligence Quotient, commonly known as the I.Q. This is measured by the following formula:

$$\text{I.Q.} = \frac{\text{Mental age} \times 100.}{\text{Actual age}}$$

The mental age of a person is determined with the help of certain tests. It has been reported in one of the studies that the average I.Q. difference in identical twin pairs reared together was 5.9 whereas the corresponding figure for the non-identicals was 9.9 points. These observations may suggest the importance of heredity. Another point which goes in favour of the idea of heredity determining the intelligence of a person is that the adopted children are, in general, less similar to their adoptive parents than the own children of a control parent group with respect to this character. In one of the studies it has been reported that the mean I.Q scores of the adopted children were related to the quality of the adoptive homes. It was further observed that there was a continuous decrease in mean I.Q. with descent in occupational status of the father from professional to the relatively unskilled occupations. These facts clearly demonstrate the modifying influence of home environment on intelligence-test behaviour. Although intelligence, as measured by I.Q., is influenced by heredity; yet education, proper guidance and hard work can alter the I.Q. with such wide limits that an individual who

starts with the I.Q. lower than another may eventually catch up and overtake him. There may be some correlation between social advantage and higher I.Q. but it is smaller than that between educational advantage and intelligence quotient. An example is provided by a pair of identical twin, one of whom was brought up in a low income group and the other in the home of a well-to-do physician. The two boys had equal number of years of schooling and were thirteen years old when tested. In spite of the social advantages for the adopted son of the physician, his I.Q. score was practically identical to that of his brother. How dangerous it is to generalize from findings in this complex field of human behaviour is shown by a pair of English twin brothers who were separated early and who lived considerably different social environments, though their formal schooling was alike. In this case, the twin who experienced the poorer environment was 19 points higher than his brother. In general, the twin studies on intelligence-test behaviour show (i) greater similarity in I.Q. of identical twins, whether reared together or in different homes, than that of the non-identical twins reared in the same home, (ii) a strong tendency of modifiability of the I.Q. score under the influence of differences in environment.

The striking similarity of monozygotic twins in both physical and mental traits contrasts with the absence of any such close similarity in the dizygotics remains a strong support for the view that neither in body nor in mind are men born alike. Manners and behaviour are doubtless determined very largely by cultural influences of the society of which the individual is a member. In fact the role of environment is as important as that of heredity itself. For example, diabetes is hereditary yet a person possessing the gene for diabetic condition may live normally if he takes a restricted diet and regular injections of insulin. So the "bad" genes of diabetes are controlled by an artificial environment of insulin and the persons live years beyond their predestined span. The differentiation of secondary sex characters is brought out by hormones. The concept of hormonal determination of sexual traits is by no means opposed to the theory of genetic sex determination. In women, for example, tumors in the adrenal gland may cause it to secrete a large amount of a male sex hormone, resulting in excessive facial hair growth, deepening of voice and other secondary male characters. This would evidently mean that the phenotypic (external) expression of a genotype is not fixed but depends on the environment in which it becomes realised. The relationship between heredity and environment, as judged by some people, has given rise to erroneous notions. Assertions are sometimes made that in man and other mammals, the developing embryo may somehow acquire a resemblance to objects seen by the pregnant mother. This is why when the sun is eclipsed some of the pregnant women in India prefer to remain inside the rooms. It is also believed by some that the general health of the parents may influence the characteristic of their progeny. These and such other beliefs have no scientific foundations.

In conclusion it may be said that characters like colour of the eye, the shape of the nose, the type of blood

group or the sex of an individual are ordinarily not influenced by the environment. The susceptibility to a disease like tuberculosis and the development of a character like intelligence or the personal temperament can be greatly influenced by environment. It has been, for example, reported that the members of an identical twin pair showed a significant difference in the development of their personalities due to the effect of city and rural brought up.

Place of Museums in Science Education

V. S. Agarwal

THE world is becoming museum conscious and the older concept of museums as store houses of queer objects has become outdated. Museums are now playing a very important role in the field of education in the world. In the U.S.A., twenty museums of old have now become more than a thousand and every School is encouraged to have its own museum. Thus it is very important to make use of museums in education for developing multipurpose activities of a child. Museums are now the centres of education, exhibitions and research in accordance with the international concept. In India too museums can play an important role in the field of school education in particular. The biological sciences, like botany, zoology can be very successfully introduced to children of high schools through museums and the most difficult topics can be presented to them in a very interesting manner.

School children in India consist of a heterogenous mixture of boys/girls coming from, rural, uneducated surroundings; from different linguistic groups, from areas hilly backward regions and tribals. A uniform type of class lessons either based on inductive methods or deductive procedures with recapitulation charts will not suffice. Further, the teacher very often has to face many problems such as the variations in intelligence quotients of different children. This would make his progress in lessons slow, and there will be lack of uniformity in the education pattern.

What is a museum? It can be said to be a centre of exhibitions of either made or collected specimens or objects arranged in a scientific manner for either educational purposes or research or both. Hence the museum includes, the collection of objects, preparation of exhibits from the collected and prepared materials, listing out in a scientific manner the various objects, the care of the objects, their labelling and finally their display. In this paper museum meant for educational activities only is being dealt with by taking a topic 'Propagation'.

Besides the museum preparation, certain other museum activities are also to be carried out under which occasional topical exhibitions, temporary arrangement of objects or collections,

making of artificial objects and sketches, dioramas can be mentioned. For such purposes lot of studies are required to be done by a teacher and a little museum training to the teachers will serve the purpose. The pupils should not be put to hard labour of studying books and making notes etc. Here the idea of a museum method is to lay emphasis on practical work to create interest among students, and not to make them, realize that books are burden to them, and induce in them a kind of love towards their studies.

Under the subject "Propagation," it is meant to teach them as to how animals and plants propagate or disperse themselves which may include dispersal of seeds in plants and natural and artificial selections, and the modes of multiplication among animals.

A museum should be organised in the following manner. Students of a class can be selected as shown below:

(1) Students who are very fond of outdoor work.

(2) Students who have a flare for writing.

(3) Energetic children are enthusiastic.

(4) Children who mix well with others social bent of mind.

They may be assigned the following tasks.

One group could be assigned collection work. They could collect specimens on holidays, bring them to the school, sort them and keep them in containers or in the dried form.

Another group can be given drawings of seeds and plants.

A third group may be given the task of labelling and preparing catch labels, labels of associate objects, side labels, specific labels and descriptive labels.

A fourth group assigned for clay modelling of those seeds which could not be collected but are important from seed dispersal point of view. On the basis of the capacity of a school, it may use microcrystaline wax, plaster of paris, etc., in place of clay to get better models.

A fifth group may be entrusted the task of taking photographs of trees, plants etc. whose seeds are dispersed in a different manner and the teacher may guide them on this matter. Here they can also be made to learn, developing and printing as well.

The last group may be asked to do the preservation and arrangement of exhibits which involves team work and artistic ornamental bent of mind.

In a similar manner, propagation by animals can be attempted when animals having power of regeneration, by budding, by fission or vegetatively, or reproduce through eggs. These can be shown effectively with interesting catch labels, models and a series of sketches or photographs.

Every year additions to the existing specimens could be made and the students will then be required to examine the museum collections frequently. Sometimes cross questioning will inculcate in them a competitive spirit. The home task from books should be avoided as far as possible.

All other topics in biological sciences can be tried in the same manner effectively. The teacher explains these natural phenomena. As the air-ship can move in the atmosphere with its rudder, wings etc and its efficient flight depends upon the velocity and direction of the wind, the winged or hairy

SEED DISPERSAL

Type of dispersal	*In the background*	*Exhibits and specimens*	*Associate object in a hanging position with its label*	*Models in the forefront*	*Catch labels*	*Side labels*	*Specific labels*	*Descriptive labels*
1	2	3	4	5	6	7	8	9
By wind	Drawings of plants with their small powder like seeds scattered over the ground & few in the atmosphere	Collected specimens in transparent containers	An airship with a small label showing clear wings, rudder etc.	Models of interesting specimens showing the structural modification of hairs, wings & flattened nature of seeds.	Air ships in plants	Small note on the types of plants, names etc. whose seeds are dispersed by winds. This label will be on the sides along with its modification.	Name of the seed whose collection is exhibited.	Distribution uses if any etc. of the plants dispersed by the wind each plant having a separate description.
By water	Drawings of plants with their seeds dispersed by water.	—do—	A ferry without oarsman	Models showing the hard & light nature of seeds.	Ferries in plants	A small note on the modification of seeds dispersed by water.	—do—	Detailed description of the water dispersed seeds. Placed below the drawings
By animals	Drawings of seeds with extra devices for attachment.	—do—	Few animals with seeds stuck on their body and a train with a ticketless traveller and T.T. catching him	Models showing the spines, hooks etc	Ticketless travellers	A small note on animal dispersed seeds with their structural modifications.	—do—	Description in detail as above.
By themselves	Drawings showing the natural explosion in seeds and fruits.	—do—	Rifle with bullet, sprayer etc.	Models showing the nature of fruits, before and after bursting.	Plant explosives	A note on self dispersed seeds as spray mechanism Bullet system in fruits etc.	—do—	—do—

seeds can also be carried away by the wind. They move in the atmosphere and wherever they fall on moist land, they stick to it and germinate. The water dispersed seeds are very hardy, resistant (to such an extent that they can remain in a viable state for 25 years or more), light (as they can float on water) so that whenever they are drifted by currents to the shores, they at once stick to the mud and germinate. Examples like coconut may be given. The seeds stick to animals who carried away to far of places and at times left on dry, sandy lands, and left to nature's mercy. If such seeds are resistant to abnormal conditions, they may be again carried away by other animals and reach destinations where they get suitable climatic conditions and germinate. Plants' fruits sometimes act as explosives. The viscum fruits burst from the apex and throw their seeds to distant places, but the eucalyptus plants burst from the middle throwing their cap first, then the seeds are pushed with a jerk one after the other like a machine gun.

In Moss sporophyte the whole spore-box is sent out like a bullet and in balsam plant the pod twists around and scatters away its seeds. Hence with such demonstrations the whole lesson becomes not only easy but very attractive.

This heterogenous type of instruction by way of drawings, attractive and interesting titles, different labels with visual demonstrations will be able to give enough of material for every type of boy/girl to grasp the subject according to his ability and intelligence. This method will surely prove effective and beneficial if implemented in all schools. If this cannot be followed in all schools of a city simultaneously for certain reasons, a good institution with enough financial backing may start a mobile museum subject-wise to assist other educational institutions of any region.

National Science Talent Search Examination, 1967 A Critical Study

VED RATNA

THE National Science Talent Search Scheme has now been in operation by NCERT for almost five years. The two chief purposes of this scheme are:

1. to locate promising students who can be considered potential scientists early at the secondary stage, and
2. to nurture the talent so that their creative powers develop in the best possible way.

To meet the first of these purposes the selection of students studying in Class XI (or equivalent) is done in three stages:

1. Only those students who have securced 55 per cent or more marks in science subjects in their annual examination of Class X are allowed to appear at an All-India examination.
2. In the examination, which is held on the first Sunday of every January, the examinees take an objective type 'Science Aptitude Test,' write an 'Essay' and submit a 'project Report' written by them earlier on some experimental or theoretical work of scientific nature done by them. On the basis of their score in these three tests, about 1200 students are called for interview.
3. As a result of the interview about 350 students are selected for the award of scholarships on the basis of their total score in the written test and interview. The scholarship is awarded with effect from the month of July every year.

Since the selection of the right type of students is the back-bone of the whole scheme, a constant evaluation of the technique of selection is extremely essential. The above described technique is intended to assess the pupils:

aptitude for science,
powers of scientific reasoning, critical thinking and skill in scientific experimentation,
ability to apply knowledge, to analyse and interpret scientific data,
ability to express scientific concepts clearly and precisely,
creativeness and mental altertness in the investigation of scientific phenomena,
awareness of the basic nature of science,
knowledge about the recent developments in the various branches of pure and applied sciences, and
skill to devise and develop some original ideas experimentally.

Although the ultimate criterion of the success of the whole scheme with reference to both the purposes mentioned above will only be the work that will be done by the awardees of this scholarship when they enter their career as full-fledged scientists, continuous effort is made by the NCERT to evaluate the existing technique of selection. In this respect, various kinds of statistical studies are undertaken every year on the data obtained from the N.S.T.S. examination and published in the form of a report. As a continuation of this process and at the suggestion of Dr Kothari, a study of the variation in the performance of students at the N.S.T.S. examination from one school to another was undertaken.

The Union Territory of Delhi was chosen for this study just as a matter of convenience.

Methods of Study

Data was collected from the results following three examinations:

(1) Higher Secondary Examination, 1967 conducted by the Central Board of Secondary Education, New Delhi.

(2) All India Higher Secondary Examination, 1967 conducted by the Central Board of Secondary Education New Delhi.

(3) Indian School Certificate Examination, Dec., 1966 conducted by the Council for the Indian School Certificate Examination, New Delhi.

In the first category, the total number of schools in Delhi is 352 of which 198 (56.25%) have science stream while the others cater to non-scientific-groups of studies only. Schools offering for the second and third examinations are too few schools (18), though all of them have the science stream. These schools are being considered as one group in this study because they are far more similar to each other in respect of educational standards and medium of instruction etc.

Out of 198 science teaching schools catering the first examination, students from only 115 schools took the N.S.T.S. examination, and 83 (41.82%) schools did not take any initiative to send their students for this examination. This shows need for publicity to the scheme by various means. Some of steps have already been taken to publicise the scheme by the NCERT. A documentary film on N.S.T.S. scheme entitled "Scientist of Tomorrow" has been prepared under the supervision of this department and has been released all over the country.

A glance at Table I shows that pass percentage as well as percentage of students getting first division is significantly higher for the schools from which students took the N.S.T.S. Examination in 1967, compared with that for the schools from which no student took the N.S.T.S. Examination. The difference between these two categories of schools may be due to standards and methods of teaching, available staff, facilities provided and admission requirements of the schools (such as minimum marks required for admissions or tests at the time of admission). In fact in some of the schools from which no student took part in the N.S.T.S. examination, a feeling may exist among students and

staff members that they can not expect any student to be selected for the award of scholarship and therefore there is no point in sending candidates for the N.S.T.S. examination.

Similar difference can be seen between the schools from which students qualified for the N.S.T.S. interview and the schools from which students took the N.S.T.S. examination but none could qualify for the interview. The difference can also be seen between the schools from which students were selected for the award of the N.S.T.S. scholarship and the schools from which students qualified for interview but none was selected for award of N.S.T.S. scholarship. These facts bring out the validity of each of the two stages of selection against the Higher Secondary examination. However, correlation between the percentage of science students selected for the award of scholarship and the percentage of science students obtaining first division, calculated for 27 schools offering High Secondary Examination from which students were selected for the award of the scholarship, is not very high ($r=0.48$, significant at 1% level, referring to Table 2. Thus, though there is a common factor between the two examinations, the N.S.T.S. examination measures a different type of ability than does the Higher Secondary Examination. The number of schools in Delhi which prepare students for the All India Higher Secondary Examination or for the Indian School Certificate Examination is too few to make a similar study in respect of these examinations.

Out of 115 science-teaching schools of the Higher Secondary Examination from where students appeared in the N.S.T.S. examination, 1967, students from only 27 (23.48%) schools qualified for the final award of scholarship. In sharp contrast to this out of 15 schools of the All India Higher Secondary Examination and Indian School Certicate Examination from where students appeared in the N.S.T.S. examination, 1967, students from 9(60%) schools qualified for the final award of scholarship. Out of these nine schools of All India Higher Secondary examination and Indian School Certificate Examination 5(55.5%), listed in table 3, have sent more than 5 percent of their science students to join the ranks of N.S.T.S. scholarship awardees, whereas out of the 27 schools of the Higher Secondary examination only 10(37%) could get more than 5% of their science students selected for the award of the N.S.T.S. scholarship. In most of the schools English language is not only the medium of education but also the dominant medium of conversation between the teachers and the taught. This may be partly a reason of these schools doing well in the N.S.T.S. examination, because both the Science Aptitude Test and Project Report are conducted through the medium of English language.

I wish to thank the Secretary of the Council for the Indian School Certificate Examination and the Secretary of the Central Board of Secondary Education, who helped me in the compilation of these results. I am also grateful to Dr Kothari for suggesting this line of investigation.

TABLE I

Performance of students at N.S.T.S. Examination in 1967, belonging to schools in Delhi preparing students for the Higher Secondary Examination of 1967

CATEGORY OF SCHOOLS	NUMBER OF SCHOOLS	NO. OF SCIENCE STUDENTS	STUDENTS PASSED IN I, II, III DIVISIONS		STUDENTS PASSED IN I DIVISION	
			No. of students	*Pass percentage*	*No of students*	*Percentage*
Science teaching schools	198	7572	5474	72.29	1004	13.26
Schools which sent pupils to National Science Talent Search examination, 1967	115	5167	3977	76.97	830	16.06
Schools which did not send students for National Science Talent Search examination, 1967	83	2405	1497	62.25	174	7.23
Schools from which students qualified for interview	61	3269	2634	80.58	664	20.31
Schools from which students took National Science Talent Search examination but none could qualify for interview	54	1896	1343	70.76	166	8.75
Schools from which students were selected for award of scholarship	27	1525	1278	83.80	417	27.34
Schools from which students qualified for interview but none was selected for award of scholarship	34	1744	1356	77.75	244	13.99

TABLE 2

Frequency distribution of schools in Delhi which prepared students for the Higher Secondary examination, 1967, of the Central Board of Secondary Education and from where students obtained the National Science Talent Search scholarship in 1967

	Percentage of students getting National Science Talent Search Scholarship				Percentage of students getting first division			
Percentage of students getting I division	**0-9.9**	**10-19.9**	**20-29.9**	**30-39.9**	**40-49.9**	**50-59.9**	**60-69.9**	**Total**
0 — 1.9	1	2	3	.	.	.	:	6
2 — 3.9	..	2	2	1	2	1	.	8
4 — 5.9	2	..	..	2	..	.	.	4
6 — 7.9	..	1	1	..	.	.	.	2
8 — 9 9	..	..	..	1	..	1	..	2
10 — 11.9	1	..			..	..	1	2
12 — 13 9	.	.		.	.	..	.	0
14 — 15.9		.	.	1	..	.	..	1
16 — 17 9	..	..	.	1	..		..	1
18 — 19.9	..	..	..		..	.	1	1
Total	4	5	6	6	2	2	2	27

r=0.48 which is significant at 1% level

An Experiment on Science Education

A. G. BHATTACHARYA
A. M. GHOSE

THE fundamental aim of Science for Children is 'to develop scientific look and to create living interest in various scientific subjects among children through diverse means. In the past the students working at the centre have shown remarkable ability in building up models, and while some of the instructors have felt that the moment was opportune for taking the decisive step of guiding students from model building hobbies to more scientifically oriented activities, other instructors were more hesistant to do so. This hesistation was based on the belief that, (i) the students do not like classroom atmosphere and (ii) the students are scared and repelled by theoretical discussions even if they are simple in nature. Science teaching in most schools in our country is carried out in an unscientific manner with the primary object of enabling students to pass examinations. The educationists are aware of this grave situation and the National Council of Educational Research and Training has undertaken the gigantic task of remodelling science education in India. Field experiments carried out under the auspices of NCERT and elsewhere have indicated that any practical efficient way of imparting scientific knowledge among children must involve direct participation of students in classroom experiments. A pilot scale experiment with a small group of children was, therefore, planned to be undertaken at the SCIENCE FOR CHILDREN[1] to examine this problem in a direct manner. It was decided at the outset to confine the experiment to a small size in conformity with the space and funds available.

Ten students participated in the experiment. The students were in the age group thirteen to sixteen (classes IX to XI) with the average age close to fourteen and a half.

The subject chosen for study was basic current electricity. The procedure adopted in the classes was as follows:

At the beginning of each class, one of the instructors gave a short lecture

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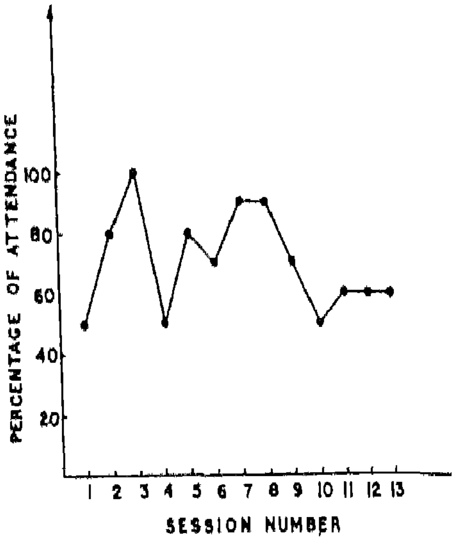
[1]Science for Children project, Rabindra Sarovar Stadium, Block VA, Calcutta.

covering some aspect of the subject under study. This was followed by questions by the students to the instructors and *vice versa*. The answers wherever possible were tested by simple experiments which were devised by the participants themselves. Also most of the primary and secondary cells used in the experiments were made by the students out of commonly available material. The topics covered in this study group were sources of current electricity, electrical constitution of matter and the concept of current as electron flow, simple circuit elements and conductivity of materials. There were 13 classes covering a period of about four months.



The attendance in this course was essentially voluntary. In absence of any other simple criterion, attendance in these classes was taken as measure of the interest shown by the students. This is shown in the graph. Although due to the small size of the sample, it is not possible to arrive at firm, indisputable conclusions from this pilot experiment, it is possible to make certain general observations. It will be seen that there was a sharp initial rise in attendance, which is probably due to the fact that the students became attracted by the novelty of the procedure. Some of the novelty-seekers were soon attracted by newer experiments held elsewhere in the centre and this accounts for the drop in the attendance. This was followed by a few ups and downs and approximately 60 per cent of the student formed a hard core which attended the classes regularly. We are therefore, safe to conclude that contrary to what has been apprehended in some quarters, students on an average, like a mixture of theoretical and experimental studies, provided that they are allowed to participate in them actively.

It was decided to extend these classes to the study of electronics including semi-conductor devices. Unfortunately lack of funds and other facilities have not allowed us to do so. However, it is hoped that in near future many such experiments will be undertaken in the SCIENCE FOR CHILDREN.

Science Nobel Laureates of 1967

R. K. DATTA

HOW do stars produce their energy has been the subject of research for last 25 years for Prof Hans Albrecht Bethe, 61, professor of theoretical physics at Cornell University, Ithaca, New York. He has recently been chosen as the winner of 1967 Nobel Prize for Physics. How do eyes see? The biochemistry, biophysics and physiology of vision has been the research of three neuro-scientists who will receive the 1967 Nobel Prize for Physiology. The recipients are Prof. George Wald, 60 of Harvard University, Prof. Haldan Keffer Hartline, 63, of Rockefeller University and Prof Ragnar Granit, 66, of Nobel Institute of Neurophysiology, Stockholm. Chemists today can assess precisely what happens in chemical reactions that occur at speeds up to one ten-billionth of a second. This has been made possible partly through longtime research of Prof. Ronald George Wreyford Norris, 70, of Cambridge University, Prof. George Porter, 47, of Royal Institution of London and Prof. Manfred Eigen, 40, of Max Planck Institute for Physical Chemistry at Gottingen, Germany. These three physical chemists have also been honoured this year by the award of this year's Nobel Prize for Chemistry.

PROF. BETHE

Prof. Bethe theorized that the energy radiated by stars comes from a thermonuclear reaction. According to his theory hydrogen nuclei form heavy hydrogen nuclei by fusion. These heavy hydrogen nuclei in turn fuse to form helium atoms. During the fusion of hydrogen atoms into helium atoms there is a loss of some matter which is converted into energy by the fusion processes. This is the source of energy of the sun and other stars. Prof. Bethe calculated the magnitude of this energy by combining known data from nuclear studies in laboratories with extensive theoretical computations. Part of his theory has already been confirmed and his calculations are of great significance in present day efforts all over the world to harness energy from reactions for peaceful uses.

Prof. Bethe collaborated with celebrated nuclear scientists, Lord Ruther

ford and Enrico Fermi, at Cambridge and Rome respectively. His early studies with them in nuclear physics gave him the basis of his theory of the sun's production of energy and of life and death of stars. His theoretical knowledge of thermonuclear reactions helped a lot in the production of atom bombs during the World War II. Prof. Bethe headed the theoretical physics department of the Atomic Weapon Laboratory at Los Alamos, New Mexico from 1943 to 1946. This laboratory was the principles installation that developed the atom bombs. In recognition of his contribution in this development the U.S. Atomic Energy Commission awarded him the Enrico Fermi Prize in 1961.

Born on July 2, 1906 at Strasbourg, then part of Germany—it is now in France, he studied in the universities of Frankfurt on Main and Munich. After a few years of teaching at universities of Stuttgart, Munich and Tubingen Prof. Bethe fled Germany in 1933 at the start of the Hitler regime and migrated to England. Later in 1935 he migrated and joined Cornell University, Ithaca, New York where he is now the John Wendell Anderson Professor of Physics. He received many awards and medals of scientific societies and is member of various associations. He is a joint-author of a book entitled Mesons and Fields (1955). Inspite of his association as a consultant with the Atomic Weapon Laboratory at Los Alamos Prof. Bethe protested against the development of hydrogen bombs.

PROF. WALD

Dr Wald's research extending over last 30 years demonstrated the molecular rearrangements when light activated the photo-receptive cells in the retina and clarified the role of visual pigments and the importance of vitamin A to visual processes. The receptor cells, also known as rods, contain visual purple (rhodopsin) which is a conjugate of a protein (opsin) and vitamin A. Visual purple breaks into protein and vitamin A when light hits retina. Visual purple is built up again in periods of darkness. Under normal circumstances the rate of breakdown of visual purple is equal to the rate of its building up. In vitamin A deficiency the rate of build up of visual purple is retarded resulting in night blindness. When the photo-receptive cells of retina are stimulated by light these chemical changes occurring in the visual purple set of electric impulses in nerve fibres, Dr Wald demonstrated.

Prof. Wald who is associated with Harvard University since 1934 and is Professor of Biology there, was born in New York in 1907. Having his education in New York University and Columbia University he received the Ph.D. degree from the latter university. Moreover, he had research training in laboratories in Berlin, Zurich and Heidelberg. His outstanding achievement in the elucidation of the biochemistry of sight won him Eli Lilly Research Award (1939), Lasker Award (1953), Proctor Medal (1955) and Rumford Medal (1959).

PROF. HARTLINE

Prof. Hartline recorded by electric means the electrical impulses from nerve cells and fibres when light struck retina. He also recorded the activity of a single visual receptor centre and developed

fibre when the receptor to which it was connected were hit by light. His research over last 30 years mostly with horseshoe crabs and cold-blooded vertebrates offered satisfactory explanation as to how the eye, by sharpening contrasts, is able to differentiate form, movement, contours, shapes and edges of objects.

Born on December 22, 1903 in Pennsylvania Prof. Hartline received the doctor of medicine degree from Johns Hopkins University in 1927 and supplemented his medical training with further studies of physics and electronics at the Universities of Leipzig and Munich. Having served as Professor and Chairman of the Department of Biophysics at John Hopkins University during 1949-53 he joined Rockefeller Institute in New York in 1953 and is now its (Reckefeller University) Professor of Biophysics. He received a number of honorary degrees and awards.

Prof. Granit

Prof. Ragnar Granit first demonstrated how different neutral units in retina reacted differently to various parts of light spectrum. He established that there were three types of cones or colour receptors in retina to receive different parts of spectrum of light. The colour message produced in brain results from an interplay of impulses from different types of cones, Prof. Granit demonstrated. His work extending over a period of 40 years also demonstrated that light not only excited but also inhibited the discharge of impulses in nerve fibres.

Prof. Granit who is head of the research organization of the Nobel Institute for Neurophysiology at Stockholm and a member of the faculty of the Royal Caroline Institute which makes the annual Nobel Medical Awards, was born on October 30, 1900 in Finland. He studied at the University of Helsinki and held teaching positions there during 1929-37. He studied under Nobel laureate Sir Charles Sherrington on some aspects of neurophysiology at Oxford. He is now in England as a Visiting Professor of Neurophysiology at St. Catherine's College, Oxford. In 1940 he joined the Royal Caroline Institute at Stockholm and was made its director in 1945. Since 1956 he has been a Visiting Professor on the staff of Rockefeller University in New York. He holds awards and honorary degrees from a number of universities and scientific societies

Prof. Norrish

Prof. Norrish and Prof. Porter did the prize-winning work together. They started their work at Cambridge University in 1949 and continued to work separately after 1955, when Prof. Porter left Cambridge University and joined the University of Sheffield. They studied the equilibrium system of chlorine gas. In this equilibrium system atoms of chlorine collide among themselves and form molecules, and molecules themselves also dissociate or break into atoms simultaneously. Prof. Norrish and Prof. Porter disturbed the equilibrium by irradiating the gas from a nearby electric spark of great intensity and short duration. As a result the equilibrium was shifted to the higher concentrations of chlorine atoms. During this disturbed equilibrium they measured the speed at which the normal number of chlorine molecules was re-established.

Prof. Norrish who is the Professor

Emeritus of Chemistry of the Cambridge University was born on November 9, 1897. He had his education at Emmanuel College, Cambridge. He served in World War I during 1916-19 Having obtained his Ph.D. and D.Sc. degree from Cambridge University he started his research career at Emmanuel College (1926-31). He joined Cambridge University as a lecturer of Physical Chemistry and was Professor and Director of the Department of Physical Chemistry of Cambridge University for 28 years (1937-65). Since 1965 he is its Emeritus Professor. In 1936 he was made a Fellow of the Royal Society. The Universities of Paris, Leeds and Sheffield honoured him with honorary degrees. He received Meldola Medal of Institute of Chemistry (1926), Davy Medal of Royal Society (1958), Liverside Lecturership of Chemical Society (1958), Lewis Medal of Combustion Institute (1964) and Faraday Memorial Lecturership and Medal of Chemical Society (1965). Prof. Norrish was elected President of Faraday Society (1953-55), Vice-President of Royal Institution of Chemistry (1957-59) and President of British Association, Chemistry section (1960-61). He is still actively busy in the laboratory pursuing his equilibrium studies with other collaborators. He spent most of the last two years travelling and visiting research institutes of the U.S.A., the U.S.S.R. and Canada.

PROF. PORTER

Born on December 6, 1920 Prof. Porter studied at Leeds University and Emmanuel College, Cambridge. He received the Ph.D. and D.Sc. degrees from Cambridge University. During 1941-45 he served in the Royal Naval Volunteer Reserve in Western Approaches and Mediterranean. He joined Cambridge University as demonstrator in Physical Chemistry in 1949 and continued till 1952. Next he became the assistant director of research in Physical Chemistry of Emmanuel College (1952-54). He was made Professor of Physical Chemistry at the University of Sheffield in 1955 and since 1963 he is the Fifth Professor of Chemistry there. He is concurrently Professor of Chemistry at Royal Institution, London (since 1963). He was elected the Fellow of Royal Society, London in 1960. He was also elected Vice-President of Faraday Society. He published a book entitled Chemistry for the Modern World (1962). He received Corday-Morgan Medal of Chemical Society (1955), Tilden Lecturership (1958) and Remsen Memorial Lecturership of American Chemical Society (1962).

PROF. EIGEN

Prof. Manfred Eigen started his research with the equilibrium of hydrogen in 1953. His system of equilibrium was concerned with hydrogen ions formed by the dissociation of water molecules. Like Prof. Norrish and Prof. Porter he disturbed the equilibrium of formation of hydrogen ions by means of a shock from an explosion or of a high-intensity electric pulse. He is now interested in applying the results of equilibrium studies to the kinetics of enzyme reactions in biological processes.

Prof. Eigen who is Professor-Director of Max-Planck Institute of Physical Chemistry, Gottingen, Germany, was born on May 9, 1927 at Bochum, Germany. Under some Germany's leading scientists he studied Physics and Che-

mistry at the University of Gottingen. He started his research studies at the Institute of Physical Chemistry of that University (1951-53. In 1953 he joined the Max-Planck Institute of Physical Chemistry of which he is now the Chairman. He is a member of National Academy of Sciences of the United States and a Visiting Professor at Cornell University, Washington University and Harvard University. He holds honorary degrees from the Washington University, University of Chicago,, and Harvard University. He received the Bodenstein-Preis Award of the Bunsen Society of which he is a member. He is also a member of Faraday Society. He published *Thermodynamics of Concentrated Electrolytes Proton Transfer in Hydrogen bonds and Chemical Relaxation* (1955-57).

The Nobel Prizes were presented to winners on December 10, the 71st anniversary of Alfred Nobel's death, in Stockholm. The 1937 prizes carry a purse of about $ 61,000.

Catalysis and Chemical Kinetics

ANTHONY TUCKER

J. J. Berzilius coined the term 'catalyst' over 130 years ago and it is 65 years since Wilhelm Ostwald defined the term to mean a substance which, in modifying the rate at which a chemical reaction approaches equilibrium, does not itself become permanently involved and, in the end, remains unchanged. The manner in which catalysts operate is still a mystery and the search for new catalysts is still essentially empirical. Much of the work is locked up in industrial security, for industry depends critically on its catalysts, but the unravelling of enzyme structures may eventually lead to an understanding of the submolecular activities which give all catalysts their mysterious properties.

A SINGLE molecule of the enzyme catalase, which breaks down hydrogen peroxide to water and oxygen, catalyzes the breakdown of almost 50,000 molecules a second, at 0°C. This incredible and specific activity represents an immensely greater efficiency than of any known inorganic catalyst. Hence the great interest in enzymes, for it is the accelerating effects of catalysts which matter most, whether in life or in industry. But catalysts are more than accelerators. In chemical systems, as in other equilibrium situations, there may be many possible points of balance. Catalysts can so modify a system that it appears to be quite different. The word 'modify' is important for, as with chemical inhibitors, the action of a catalyst is not to start some process off. At the moment the greatest effort is being put into research to try to understand how the catalyst manages its tricks of acceleration. Success could lead to immense advances in industrial chemistry, to new processes and to the tailoring of processes so that they could be controlled by computer.

What cannot be expected is an escape from the fundamental thermodynamic laws of chemistry. Catalysts can operate only on reactions which are already

From SPECTRUM 46 : 1968

possible, although they may, by "magnifying" a process too slow to be detected in normal circumstances, uncover reactions which are unknown or impractical. If, for example, a catalyst lowers the temperature at which a compound molecule will decompose, it may found that new products appear because these are stable at the new lower temperature while, in the uncatalyzed reaction, the high temperature leads to their rapid breakdown.

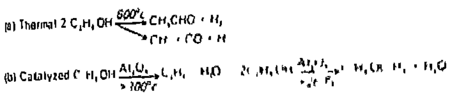


Fig. 1. Decomposition of ethanol

Diethyl ether and ethyl acetate appear only in catalyzed reactions although both are thermodynamically "permissible". At the normal thermal decomposition temperature both are unstable and therefore cannot appear.

These "new" reactions could occur only if they were already possible and the value of catalysis is that they can be exploited. But, in any reaction the catalyst modifies equally the forward and reverse processes so that the final chemical equilibrium remains the same as for the uncatalyzed reaction. In other words, there are no catalysts which simply accelerates process in one direction: the complete chemical "system" is speeded up. This aspect of catalytic action is important when seeking new catalysts, for many processes can be measured more easily in the reverse direction. It follows as a matter of basic chemical law that a catalyst for the reverse process will be just as good for the desired forward process, and this may will make the search easier.

Catalysts remain unchanged after the reaction has taken place (although they may become poisoned in time and require regeneration), but this does not mean that they do not become chemically involved during the reaction. It is now accepted that all catalytic reactions go through one or perhaps several unstable states during the cycle. In its simplest form catalyst C and reactant A create an unstable compound AC which decomposes to form products B and D while the catalyst is regenerated for a further cycle, thus A : C AC—→C ! (B · D). Because AC does not exist for long it is difficult to detect, yet its presence is clearly crucial to the changed energy requirement for the complete reaction. Modern spectroscopy has revealed many such intermediates.

In effect a catalyst changes the energy requirement for a reaction, so that, for a given input of energy, there is a much greater output of product. By its intervention and by the creation of intermediate compounds the catalyst provides a new reaction path which is more favourable. (Fig. 2) It might seem

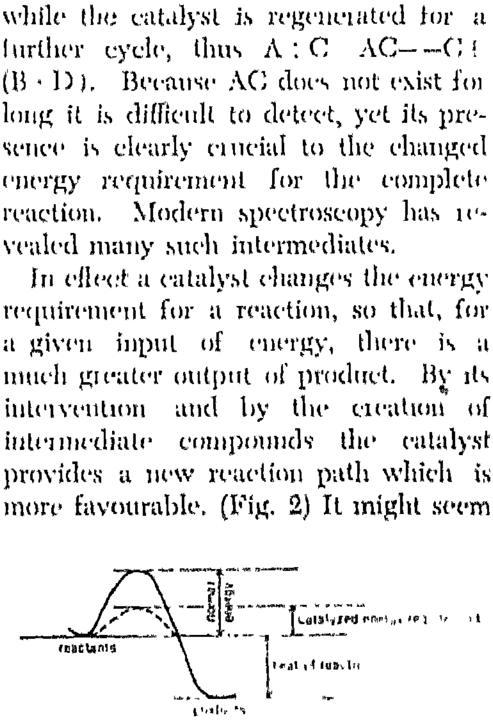


Fig. 2. Potential energy profile of a reaction
The catalyst lowers the energy barrier.

that, by the application of ultraviolet and infra-red spectroscopy, it should be possible to trace the complete reaction and find out which intermediates are involved. In practice it turns out that many unstable intermediate are made

and it is not possible to say which ones are concerned in lowering the energy barriers. The system is too complex to analyze accurately and, for that reason, most of the inferences about catalysis rest on theoretical analysis.

The situation is made even more complex by the fact that catalytic action can take place in a gas, liquid or solid (homogeneous catalysis), at an interface between them (heterogeneous), at a combination of these or in colloidal systems such as enzymes. What happens is a change of rate in some chemical exchange, but it is difficult to say how. An uncatalyzed reaction can be compared in terms of energy requirement with its catalyzed equivalent and, if the number of steps involved is known, it is possible to calculate how much energy has been used at each. This measure of 'activation energy' can give clues to the nature of the changes brought about by the catalyst and lead to conclusions about molecular and submolecular activity.

Fifty years ago the chemist Irving Langmuir put forward the idea that, in the case of inert surface catalysts such as platinum black, some kind of sieve effect was involved. His suggestion, that the platinum surface was seizing molecules and holding them in close contact so that a reaction could take place rapidly, has been replaced by more complex descriptions of electron, ion, and cation exchanges, but it remains alone in its simple clarity. The gases oxygen and hydrogen normally combine to form water at an incredibly slow pace: at a platinum surface they combine rapidly. The surface never becomes saturated because, although both hydrogen and oxygen are held, the water molecule is too large and is rejected.

This kind of explanation, which goes only part of the way, can be used to explain how some catalysts will carry out only one step with particular reactants, while others work more generally. But the ability to catalyze has no connection with the inertness or otherwise of the catalyst. Metals, metal oxides and sulphides, acids and proteins may, in some circumstances, prove to be catalysts. Those, like platinum black, which can catalyze a whole range of reactions, were inevitably the first to be discovered. Their versatility made it more difficult to grasp what was happening. Hope of understanding what goes on now rests on the most specific catalysts of all, the enzymes in living systems.

However, among the metals, those which possess catalytic properties—which at first depend on a high ability to absorb chemicals tend to lie within what is called the transition series. What makes these metals different from all the others? The answer is that, without exception, their atoms are built up so that they possess unpaired electrons in the orbit generally held responsible for magnetic properties. Curiously, the free valencies—the "unclasped grips" at the surface of these metals is attributable to incompletely field orbits of another kind, which overlap to create the metal-metal bond. In other words, many metals have free valencies at the surface, but only those with other unpaired electrons in a particular place in the atom have high chemisorption ability. This is not entirely a surface effect: some kind of deeper relationship, probably involving the distribution of charges and of changes in potential

energy patterns close to the surface must be responsible for the extra activity.

The suggestion that something of this kind is also true of the living catalysts has recently begun to emerge. Analysis by X-rays of protein structures (enzymes, the living catalysts, are all proteins) has reached the point at which several are known in detail and many more will soon be. Active groups of complex living molecules are slowly being identified as are the steps of a particular reaction In general enzymes are more specific than inorganic catalysts, often being designed to carry out only one operation, and that on particular materials in particular condition. Some simple active groups even when separated from complicated parent molecules, continue to operate as catalysts. Others will not act as catalysts if the parent molecules are changed even though they are not changed themselves. There are deep mysteries here but some tentative explanations of the general mechanism involved have been put forward. The behaviour of the simplest atomic ion—that of hydrogen—the proton, is being examined to see if some simple explanation exists.

Professor K. J. Laidler, Commonwealth visiting professor to the universities of London, Sussex and Kent during 1967, has suggested that the consideration of electrical charges in proton transfers may be able to throw light on enzyme activity.

It is already clear that proton transfers play important role in some enzyme catalyzed reactions, particularly hydrolyses, and Professor Laidler points out that some insight into the potential energy surfaces of active molecular areas can be gained from a study of the electrostatic factors alone. Laying bare even the simplest situation is still a long way

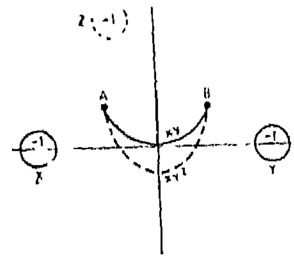


Fig. 3. Paths of least resistance for a proton in different charge situations

xy shows the path of a proton moving from A to B with negative charges at X and Y. If a third charge (+) is present at Z the path becomes xyz with a different energy requirement.

ahead, but the distribution of static charges can make considerable differences to the energy barriers in particular situations. Catalysts somehow lower the energy requirements of reactions: a change in the position of a static charge can do just that.

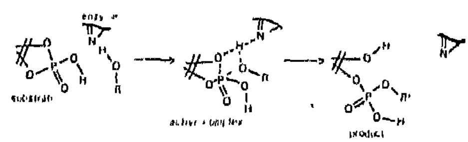


Fig. 3a. Possible mechanism of catalytic action of ribonuclease

The activating N atom belongs to histidine 119 in the ribonuclease molecule.

The big question is whether, in enzyme catalysis it will eventually be possible to dispense with much of the molecule and produce synthetically only those parts essential to a reaction. This kind of things can be done with some proteins already. Insulin (not an enzyme but a hormone with every specific action)

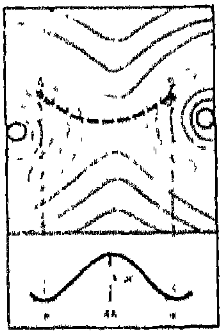


Fig. 4

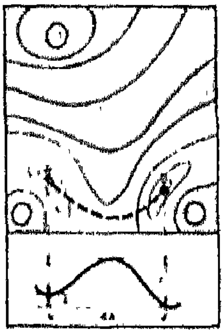


Fig. 5

Fig. 4 Potential energy surface with charge 4 Angstroms apart, proton positions A and B at 1 Angstrom and 45° to charges. The energy barrier is 71 Kcal per mole
(1 mole is the gram-molecular weight of a substance, in this case 1 (H). For HCl it would be H (1) + Cl (35.5) = 36.5

Fig. 5. The introduction of an additional charge in a particular position lowers the energy barrier in both directions. An additional charge in most other places raises the energy barrier as does an additional negative charge

Diagrams from 'New horizons in chemical kinetics', by K. J. Laidler, "Chemistry in Britain", November 1967.

differs slightly from animal to animal, in that a single group of 3 amino acids (in a chain of several thousand) is peculiar to particular animals. But the insulin from one animal is equally effective in all others the variation occurs at some non-critical point in the molecule. Similarly both hormones and enzymes can be cut down drastically in molecular size without their activity being affected provided that the essential active sites are undamaged and unchanged in their atomic relationships. So far only a few proteins have been manipulated in this way but it is quite conceivable that, perhaps within a few years, simple synthetic enzymes and perhaps other types of catalyst can be manufactured in bulk for particular processes. A new era in chemistry will be in sight.

Classroom Experiments

Experimental Demonstration on Acceleration

Bina Ghosh, Asok Sinha,
B. D. Nag Chaudhuri

THE problem a teacher faces while demonstrating acceleration to a class is the measurement of time. When it covers a certain distance of its total path, the time required by a body in most of the cases is the fraction of a second. The measurement of this small entity cannot be done by ordinary methods and requires sophistication. Multiflash photo arrangements have been suggested in PSSC physics. These methods are highly expensive and unsuitable to Indian conditions. Nuffield Physics Project of Britain and Wyndham Project of New South Wales have adopted ticker tape arrangements to demonstrate acceleration in a class. These measurements are sensitive but expensive. In the books of USSR, this demonstration on acceleration has been suggested by allowing liquid to drop from a nozzle fixed to the bottom of a cylindrical vessel. The vessel itself is kept on a small trolley which moves over a glass plate. The diameter of the cylinder is large so that the time between two successive drops is almost same. Results obtained by this method are not at all satisfactory. A simple experimental demonstration has been described in Science Master's Book Series I Part I. This experiment has been carried out with a three wheeled trolley which moves on two guides. Each guide is made of a pair of glass tubes or rails kept apart by a small glass tube between them. The vibrator is a mild-steel strip which is kept fixed to a stand. The steel strip vibrates and leaves a trail of simple harmonic impression on a vertical side fitted to the trolley. A good number of waves can be obtained by this method but the trolley used is heavy on one side and there is every possibility of it being turned over.

The trolley we used to demonstrate acceleration in a class has three wheels fitted to the base in the form of an isosceles triangle. The two front wheels from the base of the triangle whereas the rear wheel is at the vertex. Each wheel has a diameter of 2.5 cm and is provided with ball bearing arrangements. There is a stand which is connected rigidly to the centre of the trolley and bends perpendicularly at a height of 8 cm from the fixed point. A hollow but heavy pendulum with a brush at the lowest position hangs vertically from the end of the horizontal

part of the stand as shown in Fig. 1. The bob swings freely and is in contact with the surface on which the impression is to be made.

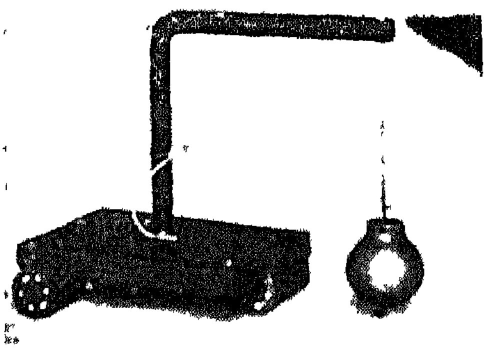


Fig. 1

A long glass plate 200 cm x 35 cm is kept horizontally on a table. The trolley is placed at one end of the glass plate and a long thread is connected to the front of the trolley. The thread passes through a pulley kept at the other end of the glass plate and then passes over a second pulley kept at a height of 90 cm and just above the first one. The other end of the thread is provided with a hanger on which weights can be placed.

The brush is soaked in ink and the bob is taken to one side and then released. A small weight is placed on the hanger and the trolley is allowed to run on the glass plate. The bob swings and leaves behind a track of simple harmonic nature on the glass plate as shown in Fig. 2. The distance covered by the trolley in each wave increases gradually and the acceleration can be calculated easily knowing the time period of the pendulum.

We obtained the following results in an experiment in the laboratory.

Mass of the trolley - 800 gm
Time period of the pendulum 0.56 sec
Mass kept on the hanger = 60 gm

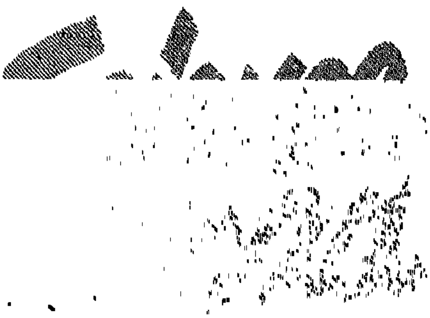
OBSERVATION I

Distance in cm	*Velocity in cm/sec*	*Acceleration cm/sec²*	*Mean Acceleration cm/sec²*
3·9	6·88		
5·8	10·35	6·02	
8	14·29	7·04	
10·2	18·40	7·34	
13	23·21	18·59	9·31
16·9	30·18	12·45	
20	35·72	9·89	
22·2	39·65	7·02	

OBSERVATION II

Distance in cm	*Velocity in cm/sec*	*Acceleration cm/sec²*	*Mean Acceleration cm/sec²*
5·8	10·35		
8·9	15·9	9.91	
12.1	21.61	8·39	
15·8	28·21	11·79	9·32
18·5	33·04	8·62	
21·4	38·21	9·23	
23·9	42·68	7·98	

Fig. 2



Trends in Biological Education—An International Review

P. Kelly

1. Introduction

'ADEQUATE instruction in biology is particularly important at this time. While chemistry was perhaps the science of the 1920's and physics that of the 1940's and 1950's, I am convinced that biology will be the fashionable science of the 1970's and 1980's (O.E.C.D., 1962).

The significance of this quotation is not so much in its substance as in its origin. It was stated by Dr. Alexander King of the Organization for Economic Co-operation and Development, an international institution devoted to economic objectives which, nevertheless, recognizes that education makes an important contribution to economic growth and that biology is one of the subjects that assists in this process. Such a point of view reflects a major change in attitude towards biological education.

The thesis that education is a stimulant to economic growth and social development has only recently been widely accepted. Previously it was commonly considered that educational change followed social change. However there is clearly a far more subtle feedback system at work, and this is particularly true of the relationship between the school curriculum and society. While it may be reasonable to assume that the content of the curriculum tends to be moulded by external social pressures, there seems to be little doubt that it feeds back into society influences that affect the rate of social and economic change. Furthermore, as education itself has become a major social institution its influence permeates other social forces and the distinction between them has become blurred.

Science subjects have more obvious economic and social benefits than many others. They are required by the scientist and technologists that are in such demand. Also, having proclaimed our times as the 'scientific age,' it is logical that we should educate our vocational non-scientists—the administrators—to fit them for it. It is these twin needs that appear to be the strongest threads in a complex web of factors that have produced the developments in science education in many

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countries in the last decade or so.

At first the physical sciences gained most attention, but more recently there are signs that there is a greater recognition of the educational importance of biology. One reason for this is the view referred to earlier, that biology is the science of the future; an anticipatory recognition that break-throughs in research comparable to the more dramatic findings of physical science are occurring, and will occur, in biology. Already research whetted the appetite, but there is still an expectancy of things to come and this, it is suggested, is in contrast with the growing public view of the physical sciences which appears to be satiated with the magnitude of the discoveries of past years and feels there is little that is fundamental to learn. Biology is seen as the base for future scientific advancement.

This growth in popularity also appears to be linked to two other influences. The first is the notion that somehow biology is understandable—a legacy of the non-mathematical image of the subject with its links with reality and the relatively infrequent use of symbolism and abstraction. Second, is the realization that many of the important problems facing mankind are biological. Population growth, food resources, radiation and fall out, public health and mental disease are some of the examples mentioned.

2. Biology in the American High School

Probably nowhere else in the world is this gain in popularity of biology more marked than in the United States. In the high schools there has been a steady decline in the percentage of students taking physics: the popularity of chemistry has remained more or less constant over the years, but the proportion of students taking biology has steadily increased so that, at present, some 80% of all students take the subject.

One of the reasons for this disparity no doubt lies in the structure of the American high school curriculum. Science subjects are usually taken in successive years: biology in the tenth grade (16-year olds), chemistry in the eleventh grade and physics in the twelfth grade. It is common practice to insist that students elect to study at least one science subject. Probably because biology is the first one offered, a number of students take it 'to get science out of the way'. Other students may take biology because they feel that is an easy subject. Nevertheless, there is a positive reason for this support for biology. Much research has shown that young people are particularly interested in the subject when it deals with Man and his well-being and applied biological topics. In American high school courses it appears that these features have been sufficiently emphasized to make biology attractive. This contrasts with the image of physics courses, for instance, which often appear to be regarded by students as 'narrowly pre-professional'.

Because of the flexibility of the American College curriculum there is not so much the feeling in the high schools that all is lost if you do not take a specific subject. It allows cultural education to flourish and considerations of a pupil's future vocation are not a dominating influence on choice of subjects. This, no doubt, also helps biology, because if choice were purely related

to vocation one would expect physics and chemistry to compete with biology to a much greater extent.

Another reason for this popularity of biology in the schools of the U.S A. lies in American society. In newspapers, journals and other media of public comment one is struck by the number of references to biological topics. There is, in addition, a widespread interest in outdoor life dating back to the days of the pioneers. While it often materializes in hunting, fishing, shooting and camping, it also produces a great concern for conversation and contributes to social attitudes that are favourably disposed towards biology.

Among Americans, also, there is an introspective willingness to examine themselves scientifically. It is this that has allowed psychology, the social sciences and studies in human biology to have developed to a greater extent than in most other countries. It has meant a willingness to accept that the study of life and particularly human beings is worthwhile.

This analysis of the climate of opinion that favours biology in the United States is clearly very generalized and hazy (Hurd, 1961). The hypothesis that comes from it is, however, much clearer. If you have a society that accepts biological considerations as part of its culture then, irrespective of the vocational value of the subject, and providing the educational system is sufficiently flexible to allow cultural education to flourish, then biology as a school subject will also flourish

3. Biology in British Schools*

In Britain too, biology has increased in popularity as a school subject. Thus between 1935 and 1959 the number of candidates offering biology at School Certificate or O-level G.C.E. standard increased more than fivefold. Yet the numbers offering physics only doubled while with chemistry there was an even smaller increase.

To some extent the rise of biology was really a rise of zoology because, at the same time, the popularity of botany as a subject at this level declined. In 1928 some 26 per cent of pupils entering for the School Certificate examination took botany, less than 1 per cent took biology Came 1950 and 31 per cent were taking biology and about 1 per cent botany.

However, biology was able to compete with the rise of general science as a subject over the same period. Indeed this was to the advantage of biology because it meant that by 1950 some 26 per cent of School Certificate entrants were taking biology within general science and so about 57 per cent of all pupils had some biological education.

TABLE 1

Total number of candidates for science subjects in the summer examinations of the School Certificates and G.C E. O—level

Subject	1935	1949	1951	1959
Biology	9,968	34,093	28,014	73,001
Chemistry	26,706	28,998	20,677	53,803
Physics	19,770	28,842	21,548	60,029

(After Tracey, G. W. (1962). Biology—Its Struggle for Recognition *Sch. Sci. Rev.* 43, No. 83)

Since the introduction of the G.C.E examination in 1951 without its compul-

*The statistics referred to in this section do not include those for Scottish schools.

sory categories of subject, the proportions of pupils taking any one subject has tended to decrease. Yet, biology has, on the whole, held its own and is currently the most popular single science subject at O-level.

It should be noted, however, that there has been a decline in the proportion of pupils having some form of biological education because of the very marked decline in the popularity of general science. This decline has not, apparently, been compensated for by adequate increase in the proportions of pupils taking other scientific subjects and hence appears to have resulted in a slight overall decrease in the proportion of pupils receiving a scientific education at this level.

This account has not considered pupils who do not take the G.C.E. Statistics are not easy to come by, and because biology is so frequently taught within a framework of general science to such pupils, it is difficult to assess its relative status.

At the sixth-form level the position is quite different; biological subjects are taken by fewer students than other science subjects. In 1928 some 28 per cent of H.S.C. candidates took physics, 27 per cent took chemistry but only 5 per cent took botany, 2 per cent took zoology and about 1 per cent biology. In 1950 the figures were 39, 37, 9, 9 and just over 10 per cent respectively. With the advent of G.C.E. the position was not altered materially. In 1961 the percentage of pupils taking these science subjects were approximately 33, 26, 5, 7 and 7 per cent. The overall decrease in these proportions can be attributed to the influence of more flexible G.C.E. regulations allowing pupils to take fewer subjects.

Between 1957 and 1960 the proportion of pupils taking science subjects at A-level increased, but since then there has been an apparent swing against science. In fact, this movement is away from the physical sciences. Biology has increased its popularity.

The difference in the status of biology at O-level and A-level G.C.E. is apparently the result of the relative influence of vocational considerations. To some extent choice of subject at O-level appears to be influenced by what occupation a pupil wishes to enter, but clearly many pupils have not made up their minds on this issue and, at this stage, schools, on the whole, are receptive to cultural subjects. Biology is

TABLE 2

Average percentage increase per year in the number of entries at A—level for science subjects

Subject	1957-60	1960-63
Biological Science	*7.3	*9 8
Chemistry	9.1	4.1
Physics	9.9	7.0

[The figures given for biological sciences include both biology and zoology. As the pupils are not allowed to take both these subjects and relatively few take botany without zoology this gives a reasonable assessment of the percentage taking biological sciences (After Pillips, C. (1965) Science and Art Subjects at G C.E Level, Times Ed. Suppl., November 1965).]

often looked upon as the 'cultural' science at O-level, view very common in girls' schools, and it is this, particularly, that explains the large proportion

of girls that take biology. With boys the potential use of the subject appears to have a greater influence. Thus, while there are approximately four times as many pupils taking biology at O-level than A-level (biology or zoology), the difference between A-level and O-level for girls is much greater.

The differences between O-level and A-level entries for physics and chemistry incidentally are not so great and, in proportion, are similar for boys and girls. The entries for both subjects at O-level are roughly three times that at A-level. These figures suggest that relatively more pupils take up physics and chemistry than biology at O-level because they wish to continue with the subjects at A-level and possibly beyond.

It seems fairly clear then that the cultural image and material value of biology has an influence in Britain as it does in the U.S.A., but it leads to a contrasting situation. At O-level, where the organization of the curriculum is adaptable and the accent is on cultural education, biology flourishes. At A-level where, there is more rigid vocational specialism, biology is much less prominent.

The cultural importance of biology also appears to be becoming more accepted by the general public in this country. Whether or not we are as biology-oriented as the Americans is anyone's guess, but particularly through that biology in the last decade has gradually acquired a wider and more interested audience. It has had a good press, and whatever reservation one may have about popularizing science it must be recognized that molecular biology and other 'popular' subjects have had considerable influence on raising the status of biology in the public mind—and hence its acceptance

A. *Cultural biology and curriculum organization*

The cultural role of biology in education is now accepted in many countries, but its status in the school curriculum varies considerably. In some countries like Sweden it has increased. In West Germany, for example, the trend has been reversed. Biology was a compulsory subject there until 1960 when, in order to allow pupils to concentrate on fewer subjects, biology, chemistry, geography and, in most schools, physics were made optional subjects. Now, a much lower proportion of pupils, in the last years of secondary school, takes biology.

The instance of West Germany highlights the way curriculum organization can influence the education a pupil receives. Another example is described in the recently published survey by the Biological Education Committee (Royal

TABLE 3

Number of entrants for science subjects at the 1963 summer examination of the G.C.E

	Biology		Chemistry		Physics	
	Boys	Girls	Boys	Girls	Boys	Girls
O—level	36,667	84,385	61,046	17 570	82,281	14,331
A—level	9,751	6,888*	22,778	5,334	32,406	5,141

*Biology here includes biology and zoology (From Dep. of Ed. and Sci. (1964). Statistics of Education, Part 3 London: H M.S O)

Society-Institute of Biology Biological Education Committee 1966) that cite school curriculum organization as a clearly defined reason why potential sixth-form biologists fail to take up biology. It is this factor, probably more than any other, that may, in a number of countries, hold up the well-defined trend towards a more prominent role for biology in the school curriculum

In this country, the proposals being discussed through the agency of the Schools Council (The Schools Council, 1966) for a less restricting sixth-form curriculum through the use of major and minor subject should, if taken up, result in an increase in the numbers taking biology. At present a number of pupils who would like to take biology with, say, the physical sciences and mathematics, in the sixth are forced to abandon it because of the timetabling difficulties; mathematics, for example, often being blocked as an alternative to biology. If a combination of biology, physical science and mathematics becomes a possibility it is a fair guess that more pupils will take biology. The sixth-forms are also taking in more pupils not aiming at the highest professional status and it is likely that this will result in a growing need for 'cultural science'. If the past is any guide to the future, it will be biology that will tend to satisfy this requirement.

There is also a growing willingness on the part of the higher education to loosen the ties of specialism with the schools. The wide range of potential vocational demands of sixth-form biology literally makes it an impossibility to construct a specialized vocational course which would suit all pupils. A-level biology has to be a broad-based, cultural course which, nevertheless, through its approach must foster those abilities and attitudes that will serve a student well in higher education. There appears to be a generous attitude in higher education to the inevitability of this situation and it means that A-level biology can be broadened and made more appealing to a wider range of pupils.

B. Abandoning biology in the sixth-form

A factor that has possibly been limiting these influences on the growth rate of sixth-form biology has been the suggestion that biological departments in universities would prefer students to go up with physics, chemistry and mathematics and without biology. According to the Biological Education Committee's survey, this may be the opinion of 'more than one Professor' but there is not evidence of it being taken up in practice.

The demand for a quantitative approach to biology and a recognition of the importance of certain aspects of the physical science to the subject is understandable enough, but to suggest that the answer is to do no biology in the sixth-form ignores three important points. First that the presence of a subject in the school curriculum acts as a stimulus to vocational choice. It is unlikely that pupils will be encouraged to become biologists by the suggestion that they should not pursue the subject. Second, that it is important that future biologists should understand the relevance of physical sciences and mathematics to their subject. In this connection there is some evidence that pupils who take biology because they feel they cannot compete with physical sciences and mathematics gain a competence in these subjects by

studying them in a biological context. Third, that biology is not just an adjunct of the physical sciences. In many aspects of the subject the conceptual approach is quite different; many areas of subject-matter have little connection with physical sciences and the intellectual implication of the biological and the physical sciences are by no means always the same. By removing biology from the basic education of future biologists there is a danger of inculcating a narrowness of outlook that will be difficult to remedy in later years.

The answer to the worry about the physical science needs of future biologists lies not in the negative approach of rejecting A-level biology but in the positive one of ensuring a flexibility in the sixth-form curriculum such as that proposed by the Schools Council and the adoption of biology rather than botany and zoology as sixth-form subjects, which will allow time for all the subjects needed by pupils to be taken.

The answer also lies in reforming the content of A-level biology courses so that they contain relevant aspects of physical sciences and mathematics. Changes in the A-level biology syllabus of various examination boards are pointers in this direction and the materials of the Nuffield A-level biology project now under trial are devised to meet this requirement. A product of such reforms may not only be that the needs of cultural education and of future biologists are met but that biology will be given what may be called an intellectual respectability that will attract bright pupils who otherwise might have preferred other subjects.

Exactly how the introduction of a significant load of mathematics and physical sciences will affect recruitment into school biology is difficult to say. The Biological Education Committee's report indicates that the lack of mathematics in biology is a potent reason at present for some pupils taking up the subject. Somehow a balance has to be achieved that will grant intellectual respectability and relevance without heightening the confusion and fears engendered in some symbols and equations. If this compromise can be achieved it will also give biology a new role in cultural education. It can become the focus through which some non-scientific pupils, unattracted directly by the physical sciences for reasons already mentioned, can obtain, if not a full, at least a fuller, scientific education. They can be introduced to the physical sciences through the back door of biology

There is, of course, no suggestion in these ideas that biology should be isolated from the other sciences. What is needed, and what appears to be happening, is a realignment of status so that biology is no longer treated as the educational Cinderella of the sciences. Providing such reforms, as have been outlined, are acceptable and implemented it would seem that we have the potential for a vigorous growth of biology in the sixth-form. It will be part of an overall move to more biology in the schools.

C. Cultural education and economic value

In Britain today there is a hesitant acceptance of the economic value of biology. In part this is a result of past misinterpretations about the national needs for biologists, doctors, etc., and there

is some likelihood that it will change. There is, for example, a growing awareness of the pressing requirements of medicine, microbiology and other subjects. The fact that a quarter of science and mathematics graduates are biologists, a proportion exceeding that for physics and chemistry as individual subjects, must presumably soon alter the image of biology as the inferior partner of the traditional scientific triumvirate (Committee on Higher Education, 1963).

Yet in British schools, as in those of many countries, the accepted role of biology is as a cultural subject. It is in this context that it has a strong enough appeal to attract a growing number of students. The social climate fosters this and the fact that it is such an international phenomenon reflects its importance. Furthermore, there are also international interactions that have stimulated this development. Following in the wake of the American curriculum developments similar reforms—although, except for the Nuffield projects, few are as extensive—have taken place in a number of countries. In virtually every case the accent has been on cultural education in biology.

At the same time development have been aided by the belief that, in the long run, economic and other, more material, benefits will arise. This is the philosophy that Dr. King expressed when he prophesied that biology will be the science of the 1970's and 1980's.

The situation is not comparable to that of earlier decades when we were concerned with the physical sciences. Then it was much more straight-forward because the benefits were easy to perceive. What actually will come from future biological research is not so clear.

What is required today is an act of faith in biology and in the long-term integratory influence of education. If, now, we provide the necessary resources not only to compete with the demand for biology as a cultural subject in our schools but also to foster its development, we will produce a biology-conscious generation in the next two decades that will be able to recognize and benefit from the fruits of biological research. If we do not do this, so much will be wasted.

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Science Abroad

The Nuffield Biology Project at O-Level

W. H. Dowdeswell

1. Introduction

THE Nuffield Foundation Science Teaching Project arose as a result of a widespread interest in curriculum reform which began to gather momentum in Britain during the late 1950's. This was due particularly to the Association Science Education (then the Science Masters' Association and the Association of Women Science Teachers), pioneer work by various individual teachers and the stimulating influence of several American projects such as the Biological Science Curriculum Study.

The project at the Ordinary level of the General Certificate of Education has consisted of three separate enterprises—in physics, chemistry and biology. Although distinct as science disciplines, the projects have maintained close links with one another being grouped together administratively under a single head—the Nuffield Foundation. The fact that in our Grammar-type schools two or even three sciences are often studied concurrently at O-level has necessitated rather careful synchronization of certain sections of the three Nuffield courses. For instance in developing the biology course it was important to make sure that assumptions made in other fields were justified and that a topic such as oxidation had been adequately covered on the chemistry side by the time it was needed in the study of, say respiration.

2. Choice of an Age Group

The mandate of the Nuffield Science Teaching Project was to consider the requirements of those children within the age group 11 to 16 years, who would normally take G.C.E. at Ordinary level. Experience gained during our extensive trials has shown, however, that especially in the early years, the materials are also of considerable value to children taking the Certificate of Secondary Education and even to those who are not.

The reason for selecting this age group was that it came from a segment of the school system where reforms could be brought about in a comparatively short time and with a minimum upset of teaching organization.

3. Aims of the Biology Course

The biology course, with which I am concerned in this article, has been developed within the following framework: (1) its primary purpose has been to

provide a sound introduction to modern biology for those children who will leave school at the age of 16 and have no more formal science teaching; (2) as a secondary requirement, it has aimed to provide a suitable background for more advanced, specialist work in the A sixth form leading to G.C.E. at Advanced level; (3) a further role has been to provide a basis for additional courses of science at sixth form level suitable for those not pursuing science as a specialist subject.

Stated in summary form, the aims of the course have been:

(a) to foster and encourage an attitude of curiosity and enquiry;

(b) to develop a contemporary outlook on the subject;

(c) to develop an understanding of Man as a living organism and his place in nature—

(i) the usefulness and social implications of biology in relation to Man's every-day needs, e.g., food and public health;

(ii) the profound influence of Man's activities on other organisms;

(iii) the way in which a study of biology enables Man to interpret observations that he makes in every-day life;

(d) to foster a realization of the variety of life and of underlying similarities among living things;

(e) to encourage a respect and feeling for all living things;

(f) to teach the art of planning scientific investigation the formulation of questions and the design of experiments (particularly the use of controls);

(g) to develop a critical approach to evidence;

(h) to develop the following ideas about biology as part of human endeavour—

(i) biology has been developing over many centuries: there are many unanswered questions about life: our ideas of life may change as new knowledge is obtained;

(ii) that biological knowledge is the product of scientists working in many different parts of the world. Its pursuit is international;

(iii) that it is based not only on observation and experimentation but also on questioning, the formulation of hypotheses, testing of hypotheses and above all on communication between people;

(iv) developments in chemistry, physics and mathematics help us to make advances in biology.

Our attempt to develop a more contemporary, experimental and enquiring attitude in teaching and learning has demanded not only consideration of what is taught (although this is obviously important) but much more of how the teaching should be conducted. Through the medium of the Texts and Guides, our aim has been to show how a more experimental approach in the laboratory (obtaining first-hand evidence) and a more critical approach to second-hand evidence (derived from the literature) can lead to a more lively and truly scientific outlook among pupils.

4. Time Allotment

For those schools following the five-year course as written, we have suggested that the allotment of teaching time should be, during the first two years: two periods per week; during the remaining three years: three periods per week (one double and one single).

We assumed the average length of a period to be 40 minutes. In addition to teaching time, we would expect the equivalent of one period to be allotted for out-of-school preparation during the first two years and one or two per week during the remaining three years. However, as our extensive trials in schools have shown, the course can be used in a variety of circumstances. Indeed, flexibility is one of its particular features enabling it to be adapted to teaching systems of widely differing kinds.

5. Publications and Other Teaching Materials

In the Nuffield Biology Course we have sought not so much to introduce new factual material, although this has been done to some extent, as to reorientate the approach to that which is already taught. This has demanded new teaching techniques and new kinds of resource material.

A. A Text for Students

When considering the form our publication should take, one of the first questions we had to answer was whether there was any justification for producing yet another textbook thereby adding to the multitude that already exists at this level. Three considerations particularly, influenced our decision that such a book was necessary:

(1) The fact that throughout the course emphasis is placed on experimentation and enquiry seemed to us to dictate that practical and theory must be closely related, the one growing out of the other. To divorce them by publishing the practical work as a separate laboratory manual would clearly have been a mistake and contrary to one of the principal aims of the project.

(2) Unlike previous biology courses at this level, great emphasis has been laid on a more critical approach to second-hand evidence—that obtained by scientists in the past on which the greater part of our learning depends. Wherever possible, instead of making dogmatic assertions of fact we have tried to provide a little of the experimental data on which particular assumptions have been based, thereby giving the student an opportunity to evaluate the evidence for himself and to draw his own conclusions. The extraction and assembling of such data has proved an extremely laborious operation requiring time and facilities not normally available to teachers. A text provides the ideal medium for presenting such material in a form in which it can most conveniently be used in teaching.

(3) By writing a text, we have been able to present biology as a unified subject thus dispelling the idea still prevalent in some quarters, of the existence of two separate disciplines, botany and zoology.

B A Guide for Teachers

As its name implies, this important book provides a commentary on the course from the teaching viewpoint. The material it contains can be grouped roughly into three kinds: (1) notes on possible methods of teaching different topics with suggestions as to how particular sections of the course might be presented from a practical and theoretical standpoint; (2) instructions regarding practical work including suggestions for introducing material alternative to that described in the text; (3) 'cookbook' information on the construction of apparatus, preparation of reagents and general laboratory know-how.

C. Films Loops

Each of these lasts about three minutes and is intended for use with projectors such as the Technicolor 800E. So far some 25 have been produced and these form an integral part of the course. They are of three main kinds: (1) dealing with dynamic processes which are not easily observable in a school laboratory such as feeding in a housefly or the life cycle of the parasite *Apanteles glomeratus;* (2) illustrating experiments which cannot at present be conducted under school laboratory conditions, for instance, the uptake of C in photosynthesis; (3) showing the sequence of a technique which the teacher would otherwise have to demonstrate to the class (probably several times), for instance, the squash method of making chromosome preparations.

The fact that the operation of the 800E projector is so simple and no blackout is required, means that there need be little formality about using films under classroom conditions. Pupils can perfectly well view the loops unsupervised, for instance as a means of revision if they find themselves in doubt about the sequence of a particular technique that they are using in their class practical work. Moreover, the fact that they are silent, means that a teacher can use the films to introduce experimental situations for discussion in class.

6. Sequence of the Course

The course is divided into five sections each lasting a year. The first two years (age range 11 to 13) represent the introductory phase, while the remaining three (age range 13 to 16) are the intermediate phase.

Introductory Phase

Year 1 Introducing Living Things.
Year 2 Life and Living Processes.

Intermediate phase

Year 3 The Maintenance of Life
Year 4 Living Things in Action
Year 5 The Perpetuation of Life

Throughout the five years a number of fundamental themes and ideas occur repeatedly and it is round these that the course has been built up. They are: (1) cycles of matter and energy; (2) structure and function; (3) interaction of organism and environment; (4) integration and homeostasis; (5) replication; 6) variation; (7) adaptation; (8) natural selection; (9) classification; (10) man; (11) mathematical relationships and experiments.

The aim of the introductory course is to provide training in observation, recording, the formulating of hypotheses and making simple deductions. In the early stages, the work is largely descrip-

tive, but it becomes more quantitative towards the end of the second year. From the third year onwards the approach is a good deal more rigorous and quantitative, and the design of experiments of a more 'open-ended' kind play an ever greater part.

The first year course opens with a brief survey of the variety of life which leads naturally into the problem of classification. This is followed by an investigation of a living organism (an earthworm) in its natural environment, the intention being to introduce students to the sort of problems that arise in biological experimentation. At this point the need to identify organisms arises and a chapter follows on the use and construction of keys and the range of variation in plants and animals. The remainder of the year is concerned with the general theme of structure and development starting with cells and moving on to reproduction and growth in living organisms, including Man. Insects provide excellent material for such studies in the laboratory and the use of locusts and butterflies, such as *Pieris brassicae*, is considered in some detail.

The second year begins with a study of micro-organisms both from an experimental viewpoint and in relation to Man's everyday life. This provides a lead-in to such subjects as public health and the control of disease. The emphasis of the course then changes towards a more quantitative approach and the consideration of sizes, shapes and movement in living things. Our aim here is to help children to appreciate the value of models, both physical and mathematical, in the solution of biological problems. By now it is summer time and we return to reproduction in plants. The course ends on a human note with a consideration of what 'growing-up' involves and finally places Man in his ecological environment with emphasis on the need for conservation.

The third-year course contains much of the material traditionally taught at this level, but the approach is much more experimental with extensive use of both first-hand evidence. Consideration of gaseous exchange leads on to respiration, food, feeding mechanisms and problems of digestion. Then follows a consideration of plants in relation to the atmosphere, photosynthesis and the organism in relation to water. The course ends with a section on ecology which places the various physiological processes considered earlier in their wider context. Since our approach to ecology differs radically from generally accepted practice, it will be considered separately.

The fourth year provides a logical continuation of the third and begins with ecology. It then takes up the story of water relations once more with a consideration of water control, substances in solution, transport and mass-flow systems. The emphasis then switches to a consideration of behaviour and the organisms as an integrated system. Study of effectors leads to sense organs, linkage systems and methods of adjustment. The kidney is used as an example of an organ concerned with homeostasis. The later chapters follow a theme of the significance of behaviour, its survival value and the organism in its environment, including parasitism. Finally we consider how Man can influence his surroundings and this leads us

back once again to conservation, now treated at a more sophisticated level.

The fifth-year course represents a radical departure from traditional teaching at this level. It begins with a consideration of the similarities and differences in living things referring back to problems already introduced at an elementary level in Year 1. This leads on to such questions as, how do similarities and differences come about, what is the material of inheritance, how do new characteristics arise and how do genes work? Investigation of the action of genes provides a lead-in to the pattern of development in living organisms and the problems of studying them. This brings us back once again to the topic of reproduction (introduced in Year 1), which is now dealt with in greater depth. The course ends with a study of genes in populations, natural selection and, finally, evolution.

7. The Role of Ecology

In devising the ecology section of the Nuffield Biology Course we have been concerned to depict the sequence of events which leads up to the establishment of a living community, thereby providing a background for the rest of the course; particularly those portions concerned with physiology, behaviour, natural selection and evolution. We have rejected any ideas that study at this level should be concerned with 'well-defined habitats' or with the bread description of 'biomes'. We begin with the fact of unequal distribution, derived from a study of *Pleurococcus* on tree trunks and palings. This raises the question of how organisms reach a habitat in the first place (some have to be moved; some can move on their own), and what problems face them in becoming established. Competition and succession finally result in the formation of an established community which is well illustrated from a study of soil or litter. Finally, the fact that organisms themselves provide habitats for others leads to a brief consideration of parasitism as an ecological relationship. Each of these stages is illustrated by a series of investigations all of which can be conducted with the minimum of equipment and within the vicinity of even the most urban school. Emphasis is placed throughout on the relationship between investigation in the field and experiment in the laboratory. This applies also in the introductory course. For instance, the study of earthworms in Year 1 involves not only outside observations but also the setting-up of wormeries for observation under experimental conditions.

8. Background Reading

A major problem of teaching at this level is providing pupils with adequate opportunities for reading outside the confines of the course. Suitable references are often difficult to find and even if they are available, their use by large numbers of students can place an intolerable strain on school library facilities. We have attempted to overcome this difficulty by providing at the end of each chapter a few pages of Background Reading. This is material intended for out-of-school use (possibly in Preparation) and covers a great diversity of topics each related to the chapter preceding it. For instance following a chapter on 'Growing Bacteria' we

have an account of Louis Pasteur, 'How Animals Feed' is illustrated by the Loudest Noise on Earth—the story of Krakatoa and its subsequent recolonization.

9. Examinations

At the outset of the Project we realized that the nature of the examinations would ultimately determine whether it succeeded or failed. If we were to alter approach to biology teaching, we had to devise a type of examination which was in sympathy with and complementary to our aims. Space does not allow a detailed account of the activities of our examinations organization, which has been concerned not only in devising new types of questions but also in a piece of fundamental research into examination procedures. Suffice it to record here two of our most significant innovations. The first of these has been the replacement of the traditional type of paper involving a few long questions by one containing numerous (about 40) short ones. This has had the dual advantage of providing a wider coverage of the syllabus and also a greater reliability in the marking. The second has been the introduction of a structured and more objective kind of test with the various types of questions categorized so that their relative proportions can be adjusted at will. The six categories we have used are:

(1) Simple recall-based question on factual material memorized by the candidate.
(2) Association recall-questions demanding the association of one piece of recall information with another.
(3) Experimental recall—concerned specifically with the kinds of experimentation which will have been carried out by the candidate
(4) Experimental design—involving the design of experiments to test particular hypotheses.
(5) Deductive—the reading of graphs and tables, formulation of hypotheses from data provided and the selection of the most likely of a number of different hypotheses
(6) Continuous prose—a short essay (about 250 words) intended to test a candidate's ability to express himself in his own words on a biological topic.

This arrangement is in marked contrast to existing examination papers in biology at O-level where the questions are almost invariably of the simple recall type. We have also considered carefully the merits and disadvantages of multiple-choice questions and have made use of them in our papers to a limited extent. In bringing about these changes in examining approach we have owed a great deal to the help and cooperation of the various Examining Boards. The fact that last July saw the second Nuffield G.C.E. O-level Biology Examination bears testimony to the degree of co-operation that has existed between the Boards and the Nuffield Biology Project. At long last we have an examination designed to conform to a mode of teaching rather than a way of teaching dictated by the nature of an examination. There is no doubt that we still have a lot to learn in this field, but at least a start has been made—we hope in the right direction

10. Trials in Schools

A feature of all the Nuffield Science

Teaching Project has been close consultation at every level of the educational edifice, particularly with schools, training colleges, technical colleges and university departments. In addition, the materials and examinations have been subjected to extensive trials under classroom conditions. During the year 1963-64 the third-year course was tried out by some 65 schools involving 100 teachers and 2500 children. In 1964-65 trials of the whole five-year course were conducted in 45 schools with 82 teachers and 4300 children. Throughout all these trials comment by teachers was sent in weekly, numerous group meetings of participating teachers were held and a reporting system was set up based on geographical areas. In the light of all this flow of information, the texts, guides and films have been extensively revised prior to their publication. Perhaps there is little need to emphasize in conclusion what, I hope, will be clear already from this account, namely that the Nuffield Biology Project has been a co-operative enterprise, not just the activity of a few individuals. The resulting course has been devised and written by teachers for teachers and has been subjected to the most exacting tests in every kind of secondary school in Britain.

Young Folks Corner

Scientists you Should Know

Dr. R. N. Rai

DR. RAM NIVAS RAI, better known to us all as Dr. Rai, relinquished his post on April 29, 1968, as the Head of the Department of Science Education after a period of five long fruitful years. His colleagues in the Department bade him farewell with mixed feelings of sorrow and delight. They were sorry that this happy association with such an eminent science educator had an end, as all good things in nature have. The delight was that they were celebrating their long association with an illustrious leader and a well-known scientist.

Dr. Rai is well known among all physicists of this country. He has been teaching physics to several batches of undergraduate and postgraduate students in Allahabad and Delhi universities. But, towards the end of his official career, he did not deem it as coming down, when he agreed to serve the cause of science education in schools He toiled in his new post with dignity and purpose, at a time when very few persons from the cita-

dels of university portals were associating themselves with matters of science education in secondary schools. He is now leaving the Department with the happy memory that due to several programmes launched by the Ministry of Education and to some extent by his own efforts, a large number of members of science faculties of several universities are now actively associated with the Department of Science Education and the National Council of Educational Research and Training in drawing up syllabi, writing of teaching materials, conducting summer schools for the talented students, helping in picking out scientifically talented pupils and in various other ways. With the retirement of Dr. Rai we can say that one glorious chapter—the first chapter—in the history of science education of this country has been completed. There are many more chapters to this book and it is for his successors and erstwhile colleagues to continue the task and guide science education into proper lines.

Young Ram Nivas spent his childhood in the village Sahandauli in Gorakhpur District in U.P where he was born on April 30, 1907. He was the eldest of three sons of Shri Triveni Rai and Smt. Urmila. He had his early education in the village school and passed the final vernacular examination in Hindi as well as in Urdu from a small town school in Gola Bazar in Gorakhpur District. Even at this early stage he showed his academic prowess by attaining distinction in mathematics. After a further study in high school with English and science subjects, and by dint of hard work and industry he secured a first division in science in the school leaving examination in the year 1926. He joined the famous Ewing Christian College at Allahabad for the collegiate classes. In the B.Sc. (Hons.) class he took physics as the main and chemistry and mathematics as subsidiary subjects. He passed the examination in the first division in the year 1931 and was ranked first. His teachers included such illustrious professors as Prof. Meghnad Saha, FRS who later became the Director of the Institute of Nuclear Physics, Calcutta, which is now known as Saha Institute of Nuclear Physics; Prof. N. R. Dhar who is now the Professor Emeritus at Allahabad University, and Prof. A. C. Bannerji who later became the Vice-Chancellor of Allahabad University. Later in 1932 Dr. Rai passed his M.Sc. course in physics also with a first class and first rank. After a period spent in research on" Propagation of electromagnetic waves in the upper atmosphere" he received his doctorate in 1934. He then entered the teaching profession by accepting the post of Lecturer at the Allahabad University. After teaching for eight years at Allahabad he joined Delhi University and continued to teach physics till the year 1959. He became Reader in the year 1948. After such a long period of teaching his services were claimed as Principal by the Sanatana Dharma College in Delhi which began its science course in 1959. He ably guided the work of this college, and moved so well with his colleagues that even now Dr. Rai is respectfully remembered both by his former colleagues at the college and also the past students.

In September 1962, he went to U.S.S.R. along with Prof. R. C. Majumdar of Delhi University, Prof. N. V. Subba Rao of Osmania University and Dr V. S. Patankar of the U.G.C. The team visited the Soviet Union and studied the science programmes. They also visited the exhibition of Soviet achievements and the Institute of Semiconductors at Leningrad. In January 1963, he was appointed the Head of the Department of Science Education of the NCERT.

At the time he joined NCERT the Ministry had already drawn up a programme for the improvement of science education. Dr. Rai applied his mind to this task and developed a programme of projects and plans for the improvement of science teaching in the school. In the beginning he had only a limited staff and for the amount of work turned out and for the amount of work he has planned for the future the number of workers in the department is none too high even now

It is not possible to single out any one programme as a highlight of Dr. Rai's tenure of office in the Department. He was keenly interested in all the aspects of the programme and developed them to very successful levels.

When the NCERT set up several panels to prepare new and modern textbooks in science subjects suited for use in Indian secondary schools, Dr. Rai associated himself actively with the physics panel, and largely by his efforts and those of the Chairman of the panel and others the first part of the physics textbook has now been published. He devoted a large amount of his time and care for the preparation of this book.

A high powered Unesco Planning Mission visited the country at the invition of the Ministry of Education and submitted a report on the teaching of science in Indian schools. Based on the recommendations of this Mission, the Department has undertaken a project of teaching of science and mathematics as individual disciplines beginning from the middle stage of the school education Dr. Rai gave able guidance to the development of this project and its details. At a time when he is leaving the Department the project has already successfully completed two years and it has spread from 31 schools to all the schools in Delhi, and some states in the country are adopting this project in a few of their schools. The teaching materials for this project have been prepared in this department. The project is now well set to venture on the second phase of the project, namely, the continuation of it in the last three years of the high/higher secondary schools.

In 1966, the Council sanctioned a new curriculum project on science and mathematics under which 20 study Groups have been established in University centres. Each study group is entrusted with the task of drawing up a curriculum in science for all students in a ten-year school. While helping the Study Groups in all subjects Dr. Rai paid particular attention to the Study Groups in Physics.

Another facet of the programme of the Department is its project for strengthening science teaching through-

out the school stage, with assistance from the UNICEF. Here also a very good working plan has been drawn up through which the Ministry hopes to distribute equipment, train teachers and produce curricula and text materials on science for all levels of the school.

On the Science Talent Search Scheme of this Department which aims to spot scientifically talented students at an early stage Dr. Rai has left the deepest impression. Many will remember Dr. Rai's role in the Interview Boards, in the organization of test papers and other matters.

Apart from these few projects mentioned, there have been several others in which he took keen interest and carried the programmes to successful levels.

He has also served as a Member of the Board of Scientific Terminology Committee of the Ministry of Education. This committee has brought out *A consolidated glossary of technical terms* in Hindi and Dr. Rai helped the physics sub-committee of this Board.

During recent years he has been taking a keen interest in the production of scientific literature in Hindi. He himself has got abundant love for Hindi and his great desire is to produce books in Hindi on scientific topics. His interest is not confined to physics. He is a keen lover of nature and shows great interest in birds and in flowering shrubs and trees. He is also interested in the latest developments in biology. His interests in physics and other science subjects is very well reflected in the choice of books he has made for the science library.

As an individual Dr. Rai is intensely human. He looks at every problem in its right perspective. He is very kind and considerate. He is always cheerful and has a keen sense of humour. As a matter of fact, when some one asked him how he keeps himself so fit, he remarked that the secret is due to the fact that he does not worry over matters but always faces them with a laugh. There are very few who combine these qualities and academic distinction.

It is hoped that Dr. Rai would continue to show interest in the progress of Science Education and particularly in the work of the Department of Science Education. His former colleagues are looking forward to act in cooperation with him in future.

Finally *School Science* wishes him well in his well-earned rest. We are very grateful for the guidance and help he has given in the publication of this journal and we look forward to useful contributions from him to this journal.

S. DORAISWAMI

Young folks corner

Roentgen's X-Rays

SEVENTY-ONE years ago, in the months of January and February, 1896, the newspapers and journals carried the sensational news that it was possible to photograph the bones of a person's hand and his other bones too without having to break the skin. The name of 52-year-old Wilhelm Conrad Roentgen, the discoverer of this new technique, was on everyone's lips.

The discovery of X-rays was more or less the result of an accident. Roentgen never made any secret of this. He was actually making some experiments into the properties of electricity in tubes that had been made as much a vacuum as possible. He had covered a vacuum tube with black paper and had turned out the lights. He was passing an electric current through the tube from the negative pole to the positive pole when he noticed that something on his desk was glowing. This was a screen covered with barium platinocyanide. He went over to examine the screen and found that it continued to glow even if it was two metres away from the tube.

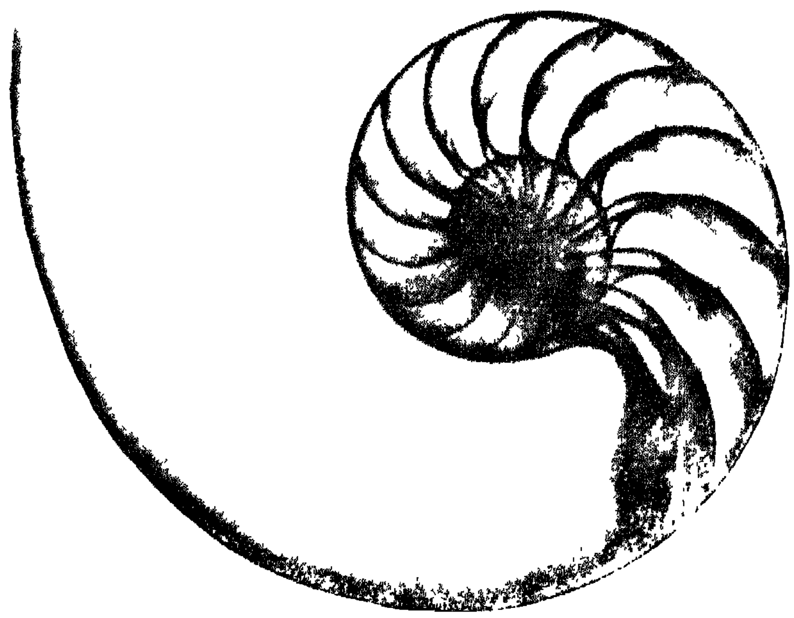
Naturally, as he was moving the screen about his hand got between it and the source of the rays in the tube. Immediately he saw that the bones of his hands were visible on the screen. Of course this was very interesting, but he would have to know something about the properties of these rays before he could see whether this dis-

From *German News Weekly*, Feb. 11, 1967

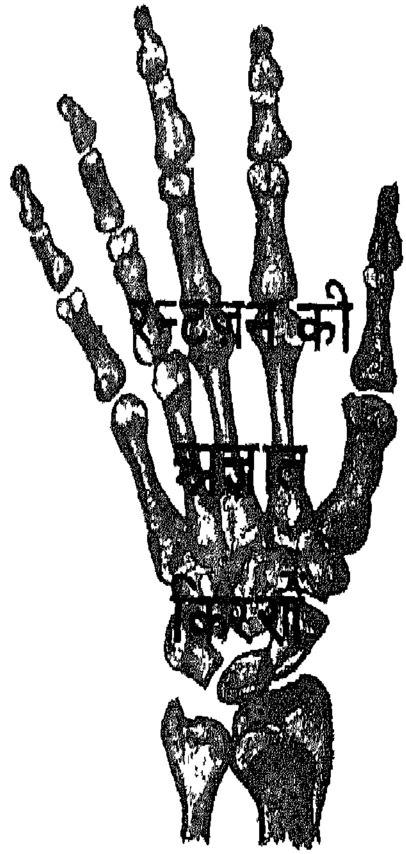
covery was of real practical value He devoted all his attention to the study of these rays and on the 23rd of January, 1896 gave the first public lecture on the subject at the University of Wuerzburg in the south of Germany. Rudolf Koelliker, a veteran anatomist, allowed his hand to be X-rayed and then the plate was developed. It was shown at the end of the lecture and caused a storm of interest. People had found that photographic plates in the vicinity of vacuum tubes through which electricity was being passed later turned out to be exposed though they had been well covered. However, Roentgen was the first man to follow this up. He was the man who not only made the observations but also drew the right conclusions.

And this was Roentgen's secret. He always called his rays X-rays standing for the unknown. In fact, a number of years had to pass before it was discovered that X-rays are in fact waves just like radiowaves though of a much shorter frequency.

Basically the X-ray machine works like this: if two metal terminals are sealed into a tube from which air has been removed so that it is a near vacuum and then an electrical current is passed between these two terminals the whole tube will glow with a rosy light as the charge passes from the negative terminal to the positive one. If this flow of current is directed at a terminal made of platinum or tungsten a ray of great penetrating power will be produced. This is the X-ray. This ray can then penetrate matter. The question now naturally arises as to why the rays go through skin and flesh but not through bone. The simple explanation is that skin and flesh are composed of oxygen, hydrogen and carbon.



And the atoms of oxygen, hydrogen and carbon have only a few electrons and protons in the case of the hydrogen atom only one of each. Such atoms are less dense than the atoms of the substances that go to make up bone such as calcium and phosphorous which have more protons and electrons. That means there is more room between them and that rays can pass through them more easily. The fact that Roentgen discovered this, though without understanding quite how it worked, was an accident. Similarly it was an accident that made it possible for Roentgen to enter academic life. For one reason or another he failed to pass his school-leaving examination and therefore could not enrol for university studies. However, he managed to go to Zurich in Switzerland where he studied mechanical engineering at a Polytechnic. Later on he showed his talents and reached German Universities.



He was awarded a number of honours for his work on X-rays but he refused to grow rich on them. He preferred, as he put it, to observe the good tradition of German professors that discoveries and inventions belong to everyone and should not, by patents, licensing arrangements and the like, become the property of single enterprises He also refused a title that he was offered. And when the day came for him to be awarded the first Nobel Prize for Physics he gave the money attached to the prize to needy children. He died on 10th February, 1923.

Unesco Pilot Project in New Approaches to Teaching in Africa

International Working Group (September 1967-Feb. 1968)

IN September 1967, the IWG assembled at University College, Cape Coast, Ghana. Work began with a consideration of a draft syllabus for junior biology, that is, the first two or three years of secondary education. Plans were also formulated for the production of teacher guides for specific topics in years 3-5 in secondary biology courses. At about the same time two trial exercises were performed, one involving colonisation of disturbed ground by a weed, the other involving succession in a freshwater environment. During this introductory period the Group received considerable advice from Mr. W. H. Dowdeswell of the Nuffield Biology Project. Work was started on section of Junior Biology.

Professor Sazonova (of U.S.S.R.) joined the Group early in November and stayed for two months. During her visit, much of the preliminary work on microbiology and parasitology was completed, both for Junior Biology and the Teacher's Guide. At about the same time, draft chapters on reproduction and nutrition were completed for Junior Biology. Mr J. Hall and Dr. L. Cole, both of the University of Ghana, visited the Group and helped in forest ecology. Partly as a result of their visit, chapters on environment for Junior Biology were drafted in rough.

During Dr. Sazonova's visit, a trip was made to the Institute of Health and Medical Research, Accra, and studies were made on malaria and schistosomiasis as well as other diseases. Mr. Talballa (from the Sudan) then arrived and during his stay with the Group discussions were held on the integration of Junior Biology with General Science. This resulted in a revised syllabus for Junior Biology, copies of which were sent to Study Groups in January 1968. The Volta Dam was visited in November. During this trip the Group received help from Professors D. W. Ewer and Lawson, both of the University of Ghana. Other members of staff of the University of Ghana also participated and introduced the members of IWG to the studies of new lake ecology.

Towards the end of December, most of the Group moved to Fourah Bay College, Freetown, Sierra Leone. Mr K. Goldberger and Mr. Coo joined

the group about this time, both are film specialists. While at Freetown two film loops were initiated: one of life history of the citrus swallowtail butterfly, the other on mangrove swamps. Plans were made for other film loops. The Group returned to Cape Coast in early January.

At the time of writing (end of February, 1968) work proceeds on revising the chapters of Junior Biology in the light of the new syllabus, and drafting the new chapters. The arrangements are made to publish the first experimental version of this material, in the form of 12 booklets, possibly with a teacher's guide. One teacher's guide for Senior Biology (in school microbiology) is in the final stage of preparation. Dr. Biran, specialist in programmed learning, joined the Group in mid-January. He started lectures in programmed learning and is preparing three programmed students booklets with the corresponding teacher's guide. Owing to the extension of contracts for both film specialists more film loops are planned.

Since the Group commenced operations in September, further participants have joined us and the following countries are now represented Botswans, Ethiopia, Ghana, Kenya, Lesotho, Malawi, Nigeria, Somalia, Sudan, Tanzania, Uganda and U.A.R.

An Insecticide From Waste Paper

A FEW years ago Professor C. M. Williams of Harvard University followed up a chance observation, and discovered that American newspapers and certain other paper products inhibit the normal growth and development of the eggs and the mature stages of a plant-eating bug, *Pyrrhocoris apterus*.

The reason for this was subsequently found to be that some trees used in the manufacture of paper, especially the fir tree (*Abies balsamea*) produced a substance, provisionally named the "paper factor" which acted on the insect in the same way as its own "juvenile hormone."

The normal effect of this hormone is to prevent the premature appearance of such adult features as wings and reproductive organs in developing insects, and its production stops when they are ready to become mature. If, however, they are then exposed to this "paper factor," it completely upsets their transition to maturity, and though possibly moulting once or twice more, these insects never become able to reproduce.

Now Professor Williams and Professor K. N. Saxena, of Delhi University, have found that the "paper factor" is also effective against a plantbug which is a considerable pest of cotton in India —the Red Cotton Bug, *Dysdercus koenigii*. This bug is a relative of *P. apterus*, and belongs to a genus of insects known as "Cotton Stainers" from their habit of piercing the cotton bolls and contaminating them with a fungus which stains the fibres.

In their experiments, Williams and Saxena used an extract of American paper towels, and found that this inhibited the bug's development, stopping the formation of adult features, and preventing the shedding of the old cuticle after moulting (*Nature*, Vol. 210, p. 440).

These workers point out that, although this is not yet a practical proposition as an insecticide, the starting materials—American newspapers and other paper products- are available in India in virtually unlimited quantities.

If a more highly purified preparation of "paper factor" can be produced, there are prospects of controlling this pest selectively The prospects are particularly good because the insects are unlikely to be able to evolve any resistance to it. This method of control would thus avoid one of the main drawbacks found in recent years to be involved in chemical control of insect pests.

From NEW SCIENTIST, 30 June 1968

Food From Natural Gas

FOR some years, research has been going on into the possibility of manufacturing human or animal foodstuffs economically from petroleum. The British Petroleum's effort to obtain protein while disposing of relatively useless waxes has been described by Alfred Champagnat and D.A.B. Llewelyn ("Protein from petroleum", New Scientist, Vol. 16 p. 612). The latest reports from this work were that large stocks of artificial protein were being built up to be used in feeding tests on many generations of animals. Esso Research and Engineering, in the United States, have been working along the same lines, and have reached a similar stage.

Meanwhile, the petroleum situation has changed with the emergence of natural gas as a plentiful raw material. And last week Shell announced that it had been exploring the conversion into protein of the lightest petroleum product of all, methane. British Petroleum have also been working on this problem, but for a rather shorter time — a little over a year — and have not yet released any progress reports.

It need cause no surprise that some sort of protein is available from methane. Indeed, it is sometimes said that there is hardly a material known of which some micro-organism cannot make good use. While some bacteria are totally dependent on a complex host environment, others have a built-in adaptability which enables a single species to use any one of over a hundred alternative organic compounds as its sole source of carbon. Many of them derive their energy by oxidizing, instead of carbon compounds, inorganic materials such as sulphur, hydrogen and combined iron. Lord Rothschild, announcing the work on methane conversion last week, said that there was one bacterium that lived exclusively on the pesticide Dieldrin.

Having found an organism which can metabolize methane (or whatever other material, looks as if it might be cheap enough to constitute a commercial proposition) the problems are to develop a good extraction process and to establish that the organism constitutes a safe and useful food.

The original British Petroleum programme is proving a protracted one. The business of extraction from the waxy substrate requires a considerable research effort: and a great deal of time is being devoted to nutritional tests with many generations of animals (see also "Notes and Comments", Vol. 21 p. 67). The company is apparently

still not prepared to make any predictions as to the economics of the process.

The Shell research, being carried out at the Milstead laboratories in Kent by Dr. J.R. Norris and Dr. D.W. Ribbons, is in a far younger stage. A few thousand pounds have been spent on it, and only enough protein has been produced for small-scale laboratory tests on such animals as rats. But at least the extraction stage appears to be quite trouble-free.

The Shell scientists are using a number of quite dissimilar bacteria, as yet unnamed, all unrelated to the petroleum-wax varieties. Indeed, methane-eaters show no interest in even the next lightest member of the paraffin series, ethane. The bacteria were bred and purified from extracts taken from a number of natural sources, including lake water and the soil of oil-bearing regions. Much of these first two years was taken up by studies of their biochemistry.

The conversion procession consists essentially in bringing a suspension of the bacteria in water into contact with methane gas. Ammonium nitrate is satisfactory as a source of the essential nitrogen, and some solids are also needed. The becterium feeds and multiplies , and is extracted from the aqueous solution centrifugally. The chief by-products are carbon dioxide and water, and the others are all apparently water-soluble.

It is estimated that a ton of bacterial protein might be obtained from three tons of methane in this way. It should be remembered that the bacteria consist of all classes of organic material — protein constitutes rather less than half their dry weight.

As to the value of the bacteria as food, it has so far been established that they seem to be non-toxic (the experimenters, as well as their laboratory rats, have eaten them with impunity). The balance of amino acids and the vitamin content have not been published, but one of the researchers has hazarded the guess that an animal might be able to live on the bacteria exclusively. This guess is academic, of course, for the aim of all such work is to produce a source of high-protein food which can be used to supplement a cheaper but deficient traditional diet.

The next step is to verify in practice these hopeful predictions of nutritional adequacy – a stage which, if the BP programme is anything to go by, can take a long time.

Like BP, Shell is unprepared to make any pronouncements on the economics of the situation, fraught as it is with the complexities of dietetics and international finance and the shifting relative prices of different fossil fuels. For the moment it is enough to say that a small stake has been laid on a line of research that offers high prizes at unknown odds.

From NEW SCIENTIST - *30*, No. 500, June 1966

Tomatoes Are Thin-skinned

TOUGH citizens devour fresh tomatoes whole, skin and all, but this, of course, is not good enough for the canning industry or for the fastidious housewife making her own soups, juices and relishes. The tomato's skin, though thin, is extremely adhesive, and its

removal poses quite a scientific problem.

There are various ways of skinning a tomato one way is to rub the surface with the back of a knife and then to scalp it; another method is to immerse the tomatoes in boiling water, drain them and skin them; a third method is to place the tomato on a fork and heat it until the skin cracks.

All these techniques have the disadvantages of taking time and of being cruel to the tomato, which retaliates by not coming up to the standards set by the United States Institute of Standards for the grading of canned tomatoes.

Scientists of the Volcani Institute for Agricultural Research Department of Food Storage and Technology, B. Juven, Z. Samish, K. Ludin and S. Zahavi, have taken the tomato in hand, and have tested various methods of peeling it, while maintaining the natural colour and firmness of the fruit required by industry.

They have compared such methods as steaming the tomatoes and then peeling them; dipping them into an 10 per cent cold lye solution ($NaOH$) followed by steaming or immersing in hot water; or dipping them into hot lye solution.

The efficiency of the lye peeling was found to depend on the concentration and the temperature of the lye solution, on the time of dipping and on whether the fruit was ripe or not. Results showed that the best method was dipping in hot lye (90-95°C) for 20-25 seconds. This provided the easiest way of peeling, as well as the highest quality of peeled tomato and the minimal peeling losses.

When 0.2 per cent detergent was added to the lye, this improved the peeling process significantly, reducing peeling losses by more than 40 per cent without affecting the natural colour and firmness of the fruit. The efficiency of the detergents tested in the lye peeling was not proportional to their effect on the surface tension of the $NaOH$ solution.

Blue Green Algae Help the Rice Crop

THE plants and bacteria which fix nitrogen, that is, absorb this valuable element from the air and make nitrogenous compounds from it, are vital to the whole life cycle on earth.

Nitrogenous compounds are scarce, and industry has had to supplement the efforts of the nitrogen-fixing organisms by artificial means, but the natural nitrogen fixers still remain the most important. The best known of them are the bacteria, such as Azotobacteria which live in nodules on the roots of leguminous plants, a partnership from which both sides benefit. But there is now a growing amount of evidence that a group of very tiny plants called the blue-green algae also play an important part in nitrogen fixing in nature, they may even be as important as the bacteria.

Blue-green algae are common on sheets of fresh water and are found forming dense masses along the margins of the sea in some temperate regions. They are also often found on the surface of wet soil, but only on the surface, since like other plants they are dependent on daylight for their growth. Their blue-green pigment traps light for energy as the chlorophyll does in green plants.

The algae are particularly common in paddy field, and within the last few years it has been realised that they are responsible for fixing and supplying much of the nitrogen needed by rice plants in the form of nitrates. In this way they are vital in providing food for more than half the world's population. The next logical step is to try to improve crop production, in particular paddy by adding artificially grown cultures of blue-green algae to the fields. Professor Watanabe, in Japan, has carried out some pilot experiments in which large cultures of blue-green algae were added to rice crops, resulting in a definite improvement in the nitrogen content of the crop and in its overall yield. At present this is not an economic process because of the high cost of culturing the algae.

Researchers under Professor Tony Fogg of the Department of Botany at the Westfield College in North London are thinking of culturing algae on a much larger scale than has been attempted so far. One idea is to grow the algae in huge vats on large open lakes.

Mr. W. Stewart of Westfield College has been investigating the possible use of blue-green algae in another agricultural role and has had encouraging results. His idea is that it may be possible to use blue-green algae to colonise barren arid soils, and so help to solve the world shortage of agricultural land. Blue-green algae are natural plant pioneers. They are very often the first plants to appear on arid soils. They are able to form a gelatinous mat, which helps to stabilise loose sand grains on the surface of the soil, by gluing them together, and they immediately start to improve the nitrogen content of the soil and so make it possible for other plants to settle, with root systems which hold the sand together more effectively and prevent erosion. The prospects for using blue-green algae as soil colonisers in this way are good, providing the culture cost barrier can be broken.

There may be a third agricultural use for blue-green algae, that is as a source of chemical extracts to encourage seed growth. Experiments in India and at Westfield College have shown that algal extracts used to treat paddy seeds make the paddy grow faster and develop more. They increase the yield of the future paddy plant and raise the protein content of the grain. No one is quite sure which element it is in the algal extract which is responsible. It may be nitrogenous compounds or plant hormones, or both. Other substances may be involved. But there is some natural biological relationship between algal compounds and rice growth, which it has now been shown, can be duplicated and artificially enhanced to improve production of the world's most important crop.

Blue-green algae are frequently the first plants to colonise arid soils. They stabilise loose sand and enrich the soil with nitrates, making it possible for other plants to get a foothold. The algae may have been one of the first organisms to colonise the land surface of the Earth, million of years ago.

In India too, a lot of work has been done and is being done on the usefulness of the blue-green algae in agriculture at Madras and Banaras Universities and in the I.A.R.I., New Delhi.

Problems in Mathematics

This feature 'Problems in Mathematics' was started in March 1967 and so far 35 problems have been published in the different issues of School Science. Students were asked to solve the problems and send their solutions before a specified date. It was also then decided that a prize would be awarded to that student who sent correct solutions.

Unfortunately, there has not been much response from students. Only a few problems (not more than 6) have been solved by students and submitted. In view of this and the fact that solutions have not been sent within the period mentioned, it has been decided not to award any prize.

The names of persons, who send solutions to not less than 50 per cent of the problems, will be published in the subsequent issue.

EDITOR

Problems 36 to 45

SS36

Show that $3^{105}+4^{100}$ is divisible by 13, 49, 181 and 379, and is not divisible either by 5 or by 11.

SS37

Divide a triangle into 19 triangles in such a way that at each vertex of the newly formed figure (and also at the vertices of the original triangle) the same number of sides meet. (In this problem the number 19 cannot be replaced by a larger number, but it can be replaced by smaller ones. Can you say which ones?)

SS38

A fly sat down at a vertex of a regular octahedron (Figure 2) and decided to visit vertices walking along its edges in such a way as to pass by each edge exactly once, and return to the starting point. Having done so, it tried again on a rhombic dodecahedron (Figure 1). Can you say whether the trial was successful?

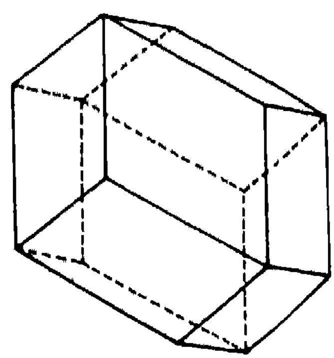


Fig. 1

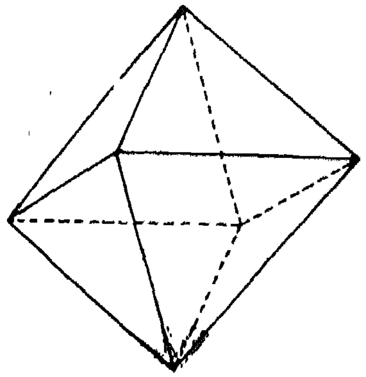


Fig. 2

SS39

Cities A,B,C,D, lie at the corners of a square with sides of 100Km. We have to so plan the railway lines that each city is joined with each of the remaining cities (junction stations other than cities A,B,C,D, are permitted), and the total length of the lines has to be minimized. How would you plan the railway lines, and what would be the total length of the railway lines?

SS40

We have 5 objects all of which have different weights, and we wish to arrange them in a sequence of decreasing weights. We possess a balance, without a set of weights, on which we can compare the objects pair-wise. How must we proceed in order to arrange the objects in the fastest possible manner (that is, by using the minimum number of comparisons)?

SS41

A rectangular card $ABCD$ is folded through one vertex A so that the remaining vertices B,C and D all fall on a side, thus forming three triangles with areas in arithmetic progression. If the area of the smallest triangle is 15 sq. cm., what is the area of the largest?

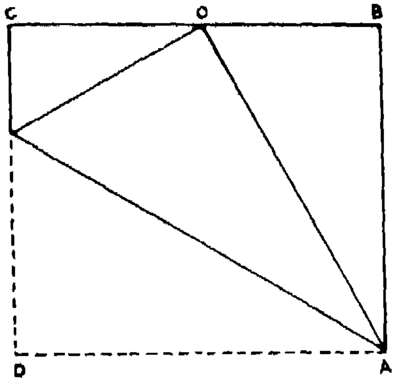


Fig. 3

SS42

Three segments 3, 4 and 5 cm. long, one from each vertex of an equilateral triangle, meet at an interior point. How long is the side of the triangle?

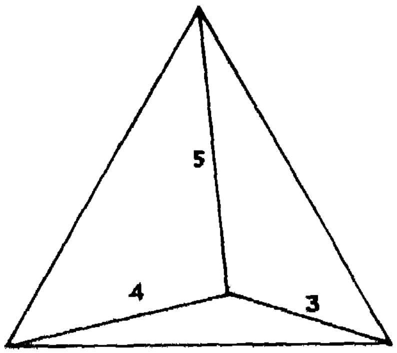


Fig. 4

SS43

What is the curve of minimum length which bisects the area of an equilateral triangle?

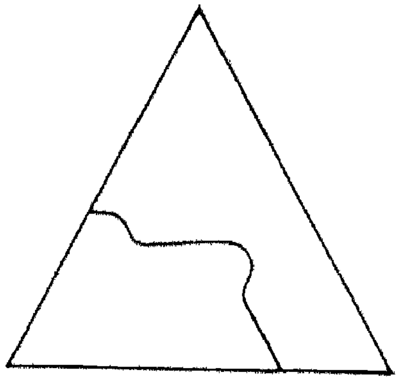


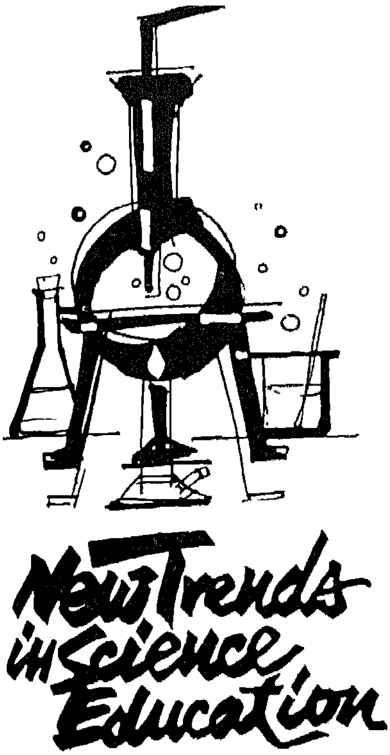
Fig. 5

SS44

The number 3 can be expressed as a sum of one or more positive integers in four ways, namely as 3, 1+2, 2+1, and 1+1+1. Show that any positive integer n can be so expressed in 2^{n-1} ways.

SS45

Show that any perfect square which has two or more digits (in the scale of 10) contains at least two distinct digits.



Summer Science Institutes (1963-67)

DURING the period 1963-67, the University Grants Commission in collaboration with the National Council of Educational Research and Training and United States Agency for International Development organised at various uiversities 172 summer institutes in science and mathematics for teachers from high/higher secondary schools/PUC/intermediate colleges attended by 6680 teachers in mathematics, physics, chemistry and biology. The number of institutes held during this period and the enrolment at the institutes are given below:

Year	No. of participants: Mathematics	Physics	Chemistry	Biology	Total No. of Institutes
1963	34(1)*	43(1)	38(1)	39(1)	4
1964	169(4)	170(4)	148(4)	153(4)	16
1965	616(16)	488(13)	464(13)	261(7)	49
1966	490(12)	468(12)	410(11)	308(8)	43
1967	747(15)	572(16)	580(16)	482(13)	60
Total	2,056	1,741	1,640	1,243	172

*Figures in parentheses indicate the number of institutes subject-wise.

The total number of American consultant associated with the academic programme of the institutes was 297.

Programme for 1968

In the summer of 1968, it is proposed to organise 56 summer institutes as follows.

Biology	12
Chemistry	15
Mathematics	14
Physics	15
Total	56

Location and Duration

The location and duration of the 56 summer institutes to be held during 1968 are given below :

LOCATION AND DURATION OF SUMMER INSTITUTES

Sl. No.	*University*	*Institute dates*	*Regions covered by the Institute*	*Director*
BIOLOGY				
EASTERN ZONE				
1.	Ranchi University, Ranchi.	3 June-13 July	Bihar, Assam, Manipur, Nagaland, Tripura and NEFA	Prof. K.C. Bose, Head of the Deptt. of Zoology, Ranchi University.
2.	Utkal University, (Regional College of Education, Bhubaneswar)	13 May-22 June	West Bengal and Orissa	Dr. (Mrs.) G.R. Ghosh, Reader, Deptt. of Botany, Regional College of Education, Bhubaneswar.
NORTHERN ZONE				
3.	Agra University, (Agra College, Agra)	27 May-6 July	Haryana, Punjab and Western U.P.	Prof. C.P. Singh, Head of the Deptt. of Zoology, Agra College, Agra.
4.	Delhi University, Delhi.	3 June-13 July	Delhi and J. and K.	Prof. B R. Seshachar, Head of the Deptt. of Zoology, Delhi University.
5.	Gorakhpur University, Gorakhpur.	6 May-15 June	Eastern U.P.	Prof. H.S. Chaudhary, Head of the Deptt. of Zoology, Gorakhpur, University
WESTERN ZONE				
6	Gujarat University Ahmedabad.	6 May-15 June	Gujarat and Rajasthan	Dr. M.S. Dubale, Head of the Deptt. of Zoology, University School of Sc. Ahmedabad.

7. Marathwada University, Aurangabad	29 April-8 June	Madhya Pradesh	Prof. K.B Deshpande. Head of the Deptt. of Botany, Marathwada University.
8. Poona University, Poona.	6 May-15 June	Maharashtra and Goa	Dr. T.S Mahabale, Head of the Deptt of Botany, Poona University

SOUTHERN ZONE

9. Annamalai University, Annamalainagar	29 April-8 June	Kerala	Dr. K. R. Ayyangar, Head of the Deptt of Botany, Annamalai University
10 Bangalore University (Central College, Bangalore	29 April-8 June	Mysore	Dr. M. Nagaraj, Deptt. of Botany Central College, Bangalore
11 Madras University, (Madras Christian College, Madras).	29 April-8 June	Madras	Dr. P.J Sanjeeva Raj, Deptt. of Zoology, Madras Christian College Madras.
12 Osmania University, Hyderabad.	29 April-8 June	Andhra	Prof. M R. Suxena, Head of the Deptt. of Botany, Osmania University

CHEMISTRY

EASTERN ZONE

13. Jadavpur University, Calcutta-32	29 April-8 June	West Bengal and Orissa	Dr. A Chakraborty, Deptt. of Chemistry, Jadavpur University.
14 Patna University, Patna.	13 May-22 June	Bihar, Assam, Nagaland, NEFA, Manipur and Tripura	Prof. J.N Chatterjea, Head of the Deptt. of Chemistry, Patna University.
15. Utkal University, (Regional College of Education, Bhubaneshwar)	13 May-22 June	Science Methods of Teachers of Training College in Eastern Zone	Dr. A.N Bose, Head of the Deptt. of Chemistry, Regional College of Education, Bhubaneswar.

NORTHERN ZONE

16. Banaras Hindu University, Varanasi.	13 May-22 June	Eastern U.P.	Dr. B.M. Shukla, of Reader, Deptt. of Chemistry, Banaras Hindu University
17. Lucknow University, Lucknow.	6 May-15 June	Delhi and Western U.P.	Prof A.B Sen, Head of the Deptt. of Chemistry Lucknow University.

18.	Punjab University, Chandigarh	6 May-15 June	Punjab Haryana, Himachal Pradesh and J and K	Prof B R Puri, Deptt. of Chemistry, Punjab University.

WESTERN ZONE

19.	Gujarat University, Ahmedabad	6 May-15 June	Gujarat, Maharashtra and Goa	Prof. A.M. Trivedi, Deptt. of Chemistry School of Sciences, Ahmedabad.
20.	Rajasthan University, Jaipur	29 April-8 June	Rajasthan	Prof. R C Mehrotra Head of the Deptt of Chemistry, Rajasthan University
21.	Vikram University, Ujjain	13 May-22 June	Madhya Pradesh	Prof. W V Bhagwat, School of Studies in Chemistry, Ujjain
22.	Regional College of Education, Ajmer	13 May-22 June	For Teachers from Training Colleges in the Zone	Dr. P D Bhatnagar, Reader, Deptt of Chemistry, Regional College of Education Ajmer

SOUTHERN ZONE

23.	Andhra University, Waltair.	20 May-29 June	Andhra	Prof. M. N. Sastri, Deptt. of Chemistry, Andhra University.
24.	Annamalai University, Annamalainagar.	29 April-8 June	Madras and South Kerala	Dr. K. Ganpathy, Reader, Department of Chemistry, Annamalai University.
25.	Bangalore University (Central College, Bangalore.)	29 April-8 June	Mysore and North Kerala	Prof. M. Shadaksharswamy, Principal Central College Bangalore
26	Osmania University, Hyderabad.	13 May-22 June	Sequential	Prof. V.R. Srinivasan, Deptt. of Chemistry, University College of Science, Hyderabad.
27.	Mysore University, of Education, Mysore. (Regional College)	29 April-8 June	Teachers from Training Colleges in the Zone	Shri S.R. Rao, Reader, Deptt. of Chemistry, Regional College of Education, Mysore.

MATHEMATICS

EASTERN ZONE

28.	Calcutta University, Calcutta.	13 May-22 June	West Bengal, Assam, Nagaland, NEFA, Manipur, and Tripura	Prof. S.K. Chakravarti, Head of the Deptt. of Mathematics, Calcutta University.

29.	Jadavpur University, Calcutta-32	29 April 8 June	Bihar and Orissa	Dr. D.K. Sinha, Reader Deptt. of Mathematics, Jadavpur University.

NORTHERN ZONE

30.	Allahabad University, Allahabad	13 May-22 June	Eastern U.P.	Prof. R. S. Mishra, Deptt. of Mathematics, Allahabad University
31.	Delhi University, (Ramjas College, Delhi)	20 May-29 June	Delhi	Principal P D. Gupta, Ramjas College, Delhi.
32	Kanpur University, Kanpur.	13 May-22 June	Western U.P.	Prof. S P. Nigam, Head of the Deptt. of Mathematics, D.A.V. College, Kanpur.
33.	Kuruksetra University, Kurukshetra	13 May-22 June	Haryana, Punjab Himachal Pradesh and J. and K.	Dr. C. Mohan, Reader Deptt of Mathematics, Kurukshetra University

WESTERN ZONE

34	Marathwada University, Aurangabad.	29 April-8 June	Maharashtra	Principal, A N. Chikhalikar, Devagiri College, Aurangabad.
35.	Nagpur University, Nagpur	29 April-8 June	Madhya Pradesh	Dr. B.S. Fadnis, Head of the Deptt. of Mathematics, Nagpur University.
36.	Poona University, Poona.	22 April-1 June	Teachers from Poona Schools and Goa	Prof. V S Huzurbazar, Head of the Deptt. of Mathematics and Statistics, Poona University
37.	Sardar Patel University, Vallabh Vidyanagar	6 May-15 June	Gujarat	Dr. B S Yadav, Deptt. of Maths Sardar Patel University.
38.	Rajasthan University, Jaipur	20 May-29 June	Rajasthan	Prof. G. C Patni, H.D. of Maths, Rajasthan University.

SOUTHERN ZONE

39	Bangalore University, (Central College, Bangalore.)	29 April-8 June	Mysore and Kerala	Prof. F. J. Noronha, Head of the Deptt of Mathematics, Central College, Bangalore.
40.	Madras Institute of Technology, Madras	22 April-1 June	Madras	Prof Surya Prakash, Deptt of Mathematics, Madras Institute of Technology, Madras.

41.	Osmania University, Hyderabad	6 May-15 June	Andhra Pradesh	Dr. Afzal Ahmad, Reader, Department of Mathematics, Osmania University

PHYSICS

EASTERN ZONE

42.	Gauhati University, Gauhati.	13 May-22 June	Assam, Tripura, NEFA, Nagaland and Manipur	Prof. H Goswami, Deptt. of Physics, Cotton College Gauhati
43	Jadavpur University, Calcutta-32	29 April-8 June	Bihar, Orissa and West Bengal	Dr B. Bhattacharya, Reader, Deptt. of Physics, Jadavpur University.

NORTHERN ZONE

44.	Agra University, Agra.	13 May-22 June	Western U.P	Prof D.R. Khandelwal, Head of the Department of Physics, Agra College, Agra.
45.	Punjab University, Chandigarh.	29 May-6 July	Punjab, J and K Himachal Pradesh Haryana and Delhi	Dr. B C. Pandey, Deptt. of Physics, Punjab University.
46.	Banaras Hindu University, Varanasi.	13 May-22 June	Eastern U P.	Dr. G.K. Das, Deptt. of Physics, Banaras Hindu University.

WESTERN ZONE

47.	Gujarat University, Ahmedabad.	6 May-15 June	Rajasthan	Prof. P.D. Pathak, Head of the Deptt. of Physics, University School of Sc. Ahmedabad
48.	Sardar Patel University, Vallabh Vidyanagar.	1 May-8 June	Gujarat	Prof. A.R. Patel, Head of the Department of Physics, Sardar Patel University.
49.	Shivaji University, Kolhapur.	13 May-22 June	Maharashtra and Goa	Prof. V.S. Patankar, Head of the Department of Physics, Shivaji University.
50.	Saugar University, Sagar.	6 May-15 June	Madhya Pradesh	Dr. J. D. Ranade, Reader, Deptt. of Physics, Saugar University
51.	Udaipur University, Udaipur.	13 May-22 June	Sequential	Prof. J. Verma, Head of the Deptt. of Physics, M.B. College, Udaipur.

SOUTHERN ZONE

52.	Andhra University, Waltair.	13 May-22 June	Andhra	Prof. T. Thirvenganna Rao, Deptt. of Physics, Andhra University,
53.	Annamalai University, Annamalainagar.	22 April-31 May	Madras	Prof. S. Sriraman, Head of the Department of Physics, Annamalai, University.
54	Bangalore University, (Central College, Bangalore)	6 May-15 June	Mysore	Dr. K N. Kuchela, Head of the Deptt. of Physics, Central College Bangalore.
55.	Kerala University, Alwaye-4	22 April-1 June	Kerala	Prof. K. Venkateswarlu, Head of the Deptt of Physics, Kerala University Centre, Alwaye-4.
56.	Mysore University, (Regional College, of Education, Mysore)	1 May-11 June	Teachers from Training Colleges in the Zone	Dr G S Srikantia, Head of the Department of *Physics*, Regional College of Education, Mysore.

(See also table on next page.)

Summer Schools for Science Talent Scheme Students

Director/Venue of the Summer Schools, May-June 1968

	I year	Duration	II year	Duration	III year	Duration
Physics	*Dr. J. Mahanty,* Head Deptt. of Physics, Indian Institute of Technology, Kanpur.	24.5.1968 to 22.6 1968	*Dr. S.C. Jain,* Head of the Physics Department, I.I T., Hauz Khas, New Delhi.	6.5.1968 to 1.6.1968	*Dr. A.K. Saha,* Saha Institute of Nuclear Physics Calcutta	
	Prof. B.G. Gokhle, Head of the Physics Department, University of Lucknow, Lucknow.	27.5.1968 to 22.6 68	*Prof. B. Dayal,* Head of the Physics Department, B.H.U., Varanasi.	22.5.1968 to 21 6.1968	*Prof. R P. Singh* Head of the Physics Deptt., Indian Institute of Technology Powai, Bombay-76	6 5.1968 to 5 6 1968
	Prof. H.S. Hans, Head of Physics Department University of Punjab, Chandigarh.	1.6.1968 to 30.6.1968				
Chemistry	*Dr. L. K Ramachandran,* Reader, Deptt. of Chemistry, Osmania University, Hyderabad.	27.5.1968, to 22.6 1968	*Dr. V.K. Phansalkar,* Prof. in Physical Chemistry, Poona University, Poona	1 5 1968 to 30.5.1968	*Dr M V R Rao,* University of Delhi, Delhi	6 5.1968 to 5 6.1968
Maths.	*Dr. J.N. Kapur,* Head of the Maths. Deptt., I.I T. Kanpur (Venue. M.K.P. Post-Graduate College Dehradun)	20 5.1968 to 18.6 1968	*Dr. R.S. Varma,* Head of the Maths Deptt., University of Delhi, Delhi.	6 5 1968 to 4.6.1968		
Biology	*Prof. A. Abraham,* Deptt. of Botany, Kerala University, Trivandrum.	15.5.1968 to 14.6.1968	*Prof. T.V. Desikachary,* Madras University, Madras	15.5.1968 to 13.6.1968	*Prof. B.R. Seshachar,* Head of the Zoology Deptt., University of Delhi, Delhi.	15.5.1968 to 14 6.1968

SCIENCE AND MATHEMATICS TEACHING PROJECT

Part three of the trial edition of the text materials for Class VIII in biology, chemistry, physics and mathematics were completed. These manuscripts have been sent to the press for printing and it is proposed to publish at least the first part of each subject in time for use at the summer course by the participating teachers to be held at the Department in the middle of June, 1968. The corresponding teachers' guide material has also been prepared and these will be cyclostyled and used at the Summer Course.

The Summer Course lasting for 16 days will be held for the science teachers of the 31 experimental schools from the middle of June, 1968. At this Summer Course, the participants will be exposed to methodology lectures, the content matter of the text material and the laboratory work and demonstration experiments. This will be done with the help of UNESCO experts and will be conducted by the staff of Science Department. With the training of these teachers for the 8th class course, the training for the middle school will be completed. The Department is at the same time preparing the syllabus and curriculum for the next stage of the school education namely class IX, X and XI.

A number of States have begun to show interest in extending this project in their States and placing a few schools on an experimental basis under this scheme. In order to acquaint officers of the Department of Education in these States, a seminar was conducted for a week from March 25 to March 30, 1968. State Institutes of Education or the State Institute of Science Education of the following states sent their representatives:

Madras, Gujarat, Rajasthan, Kerala, Andhra Pradesh and Maharashtra.

At this seminar the programme of the project was discussed in detail by these participants with the officers of the Department and UNESCO experts. Various points for clarification were raised and discussed. The participants were also supplied with a lot of literature and other materials necessary to them to prepare their own variation of the curriculum.

Following this seminar, the states of Andhra Pradesh and Gujarat have decided to start the teaching of science as

separate disciplines in a few of their schools. The Andhra Pradesh educational Department held two meetings of working groups in each subject consisting of school teachers and curriculum experts to plan out the scheme of the project in their states. They invited subject specialists from the Science Department of the NCERT and some UNESCO experts, who helped them to adapt the curriculum which was drafted to suit the educational structure of the middle school in Hyderabad, where there are only two classes namely classes VI and VII of the middle school. The curriculum was modified to include all important concepts within the period of two academic years.

Union Territory of Delhi

The Directorate of Education in Delhi has decided to introduce the teaching of science as separate subjects in all the schools of Delhi from the year 1968-69. The science centre at the Directorate organised a few seminars for biology and physics teachers in order to train them to handle class VI materials prepared by this Department under the project of science teaching. Officers of the Department closely cooperated and acted as resource persons at these seminars, and gave guidance to the teacher trainees.

The Gujarat State has also planned to start a few schools under this project and use the materials prepared by the Science Department. The Officers of the State were helped in adopting the materials to suit their schools.

Other States like Kerala and Madhya Pradesh are also showing interest in this project.

As already stated, the Central Schools Organisation are continuing to use the textbooks and materials prepared by this Department under the project in about 120 schools run by them.

Biology Study Groups

Text materials and teachers guides for classes V, VI and VII were finalized and made pressworthy along with the illustrations. These materials have now been sent to the press for printing as trial editions. These editions will be tried out during the next academic year in each region of the study group. Among the 19 Supplementary Readers planned for use by the students, the Convener of the Study Groups has already received manuscripts for two books and these are being reviewed in order to get them printed.

The Directors of the various groups met at Delhi in April and finalized the draft syllabus and chapter headings for the text materials for the next stage of the school namely classes VIII, IX and X. The most recent concepts and understanding in biology are included in the curriculum and the details will be brought to a level where the pupils would acquire enough depth of knowledge so that they can enter college education with greater understanding and depth of knowledge.

A writing session at Kodaikanal for a month was held during May to write out the first draft of a few chapters on the syllabus for these classes.

Chemistry Study Groups

The Study Groups under this subject held a writing session in Hyderabad in March, 1968, when the final drafts for

the text and laboratory manual and teachers guide were edited. Part of the materials has now been sent to the press and it is expected that the books will come out in the course of the next three months.

Physics Study Groups

The Study Groups of this subject have finalized the materials for the first year of the middle stage. Work is considerably progressing on the other two groups and the manuscripts are being processed for printing.

Mathematics Study Groups

Curriculum guides for classes V and VI in geometry and for classes V, VI and VII in algebra have been prepared. The manuscript of the text books for these classes have also been prepared. They are in the final draft stage. After a few revision touches they will be ready for the press. Preliminary discussion for the framing of the syllabus for classes VIII, IX and X were held during the three months

Regarding the primary classes, the guide for Class I is ready and that for Class II has almost been completed.

This is a scheme where the Government of India with the assistance of the UNICEF will make arrangements to provide a set of equipment to all key institutes and selected schools. The list of equipment was drawn up by the Department The Department has also prepared, under this project, new curriculum for primary school in science which would be tried out in some selected schools. The Department has already prepared the syllabus for classes I to V. Based on this syllabus, it has also developed three volumes of a handbook of science for primary school teachers.

A seminar of primary science education was held at the Department of Science Education from March 18 to March 23, 1968. The following Stataes sent representatives:

Gujarat, Himachal Pradesh, Rajasthan, Kerala, Orissa, Goa and Madras

The first volume on 'General Science for Primary schools—A Teachers Handbook of Activities' was published and the second and third volumes are expected to be out of the press very soon.

A demonstration set of equipment consisting of about 600 items was held at the Instructional Material Centre of this Department during the seminar reported above. Textbooks for the classes III, IV and V are being prepared in the Department. The syllabus is mainly activity based and the book of activities suggests a number of student activities with a lot of suggestions for the teachers as to how to organize these activities.

The science aptitude test was held on the 7th January, 1968, and about 7700 students took the test in about 326 centres distributed all over India. The scripts were evaluated and the results tabulated. About 1000 candidates were called for interview at five centres namely Delhi, Calcutta, Bombay, Bangalore and Chandigarh under the Chairmanships of Dr. D. S. Kothari, Prof. A. K. Saha, Prof. V. T. Chiplonkar, Dr. P. L. Bhatnagar and Dr. P. N. Mehra.

Fifteen summer schools each of 30 days duration for the under-graduate awardees were held at various centres during May-June, 1968. The awardees

in the M.Sc. class were attached to Scientists for research programmes at about 26 national laboratories and other institutions.

The following publications were brought out during this period:

1. Statistical Report for 1965
2. Essays by Young Scientists, 1966 English
3. Essays by Young Scientists, 1966 Hindi

The Instructional Material Centre of the Department displayed textbooks and articles of equipment developed under the 'Project of Teaching of Science and Mathematics at Schools' and at the 'Project for Strengthening of School Teaching at all Levels' at the time of the seminars of state representatives reported earlier.

The frames for the filmstrips prepared under three titles of the Department of Audio-Visual Education were examined by subject specialists in this Department. Suggestions were made for finalizing three titles, namely (i) Animals without Backbones; (ii) Pollination, and (iii) Birds.

The purchase of equipment and chemicals for the different laboratories was continued.

The first Reader under the scheme namely 'The Universe' by Prof P.L. Bhatnagar has been published. The printing of the other two titles namely 'Weapons Old and New' and 'Life and Work of Meghnad Saha' has also been completed. The manuscript of 'Animals without Backbones' was received and reviewed.

NATIONAL SCIENCE TALENT SEARCH EXAMINATION, 1968
RESULT

List of the candidates who have been selected for the award of scholarship and certificate of merit under the National Science Talent Search Examination, 1968. Their names have been arranged in order of merit.

Vadakkedathu Thomas Rajan who ranks first

Jayanta Narayan Choudhuri who also ranks first

Vijaylakshmi Shetty who ranks first among the girl candidates

RANK NO	ROLL NO.	NAME OF THE CANDIDATE	MARKS OBTAINED	STATE
1	32986	Sh. Vadakkedathu Thomas Rajan	195	Bihar
1	6011	Sh. Jayanta Narayan Choudhuri	195	Assam
3	10747	Sh. Ramesh Narayan	192	Madras
4	2096	Km Vijaylakshmi Shetty	191	W B
5	32752	Km Kalyani G. Menon	190	U.P.
6	2007	Sh Rentala Chandrashekhar	182	W.B
7	811	Km. Neelam Verma	181	Delhi
8	4815	Sh. Gadgil Ashok Jagannath	177	Maharashtra
9	1178	Sh Amitabh Jain	176	Delhi
10	498	Sh. V R. Muralidharan	174	Delhi
11	32688	Sh Dipankar Pramanik	173	Maharashtra
11	32916	Sh. Rustom Adi Kanga	173	Maharashtra
13	501	Sh. K.R. Subramanian	172	Delhi
14	22110	Sh. S.A. Prasad	171	Mysore
15	23037	Sh. R. Srinivasan	170	Mysore
16	50201	Sh. Surjya Kumar Bhattacharjya	169	W.B
17	10779	Sh. C Jayaprakash	168	Madras
18	499	Sh. K.S. Sridhar	167	Delhi
18	21649	Sh. Sudhin Dutta	167	W B
20	28033	Sh Sakate Deepak	166	Bihar
21	30191	Sh Chetan Prakash	165	Rajasthan
22	198	Sh Vijay Luthra	163	Delhi
22	4801	Sh Srinivasan Sekar	163	Maharashtra
22	10802	Sh. Vilayanur Subramanian Ramachandran	163	Madras
25	24552	Sh. Varun Bharthuar	162	Bihar
25	34216	Sh Chandan Sen	162	W.B.

1	2	3	4	5
27	37669	Sh. Dilip Kumar Mishra	161	Bihar
28	32847	Km. Vandana Shiva	160	U.P.
28	15086	Sh. Nishith Kumar Mitra	160	M.P
28	14437	Sh. Ramakrishnan Venkataraman Ramakrishnan	160	Gujarat
31	50058	Km. Sujata Mukherjee	159	W.B
31*	770	Km. Bharathi Kammeni	159	Delhi
31	1091	Sh. Amitabh	159	Delhi
31	32573	Km. B. Rajeswari	159	Mysore
35	2005	Sh. Prabhas Pramanik	158	W.B.
35	789	Km. Uma Chattopadhyaya	158	Delhi
35	387	Km. C.S. Vatsala	158	Delhi
35	1053	Sh. Rajiv Malhotra	158	Delhi
35	30149	Km. Saroj Bala Kukreja	158	Delhi
35	7731	Sh. U.V. Mathew	158	Kerala
35	27838	Sh. V.N. Dwarkanath	158	A.P
42	769	Km. Rajesh Gautam	157	Delhi
42	43454	Sh. Sanjay Gupta	157	U.P.
44	6300	Sh. Amaresh Mahapatra	156	Maharashtra
44	7190	Sh. C. Sreekumar	156	Kerala
46	781	Km. Ruchira Mitra	155	Delhi
46	502	Sh. C.S. Sundar	155	Delhi
46	32745	Sh. Dhir Shankar Mathur	155	U.P
46	30189	Sh. Ram Rao	155	Rajasthan
50	2093	Sh. Parthasarathi Mitra	154	W.B.
50	815	Km. Sudha Sehgal	154	Delhi
50	1181	Sh. Ravindra Bhatt	154	Delhi
50	17901	Km. Richa Puri	154	U P.
50	47351	Km. Rita Goswami	154	Assam
50	3639	Sh. Paul Sudhir	154	Maharashtra
50	23043	Sh. P. Ramana Kumar	154	Mysore
57	50789	Sh. Ram Chakraborty	153	W.B.
57	38850	Sh. Pradeep Kumar Mukherjee	153	U.P.
57	32919	Sh. Farokh Jal Deboo	153	Maharashtra
57	8089	Sh. P. Balagopal Kurup	153	Kerala
57	23030	Sh. Masood Ahmed Shariff	153	Mysore
62	393	Km. Janaki Srinivasan	152	Delhi
62	1039	Sh. Arvind Kumar Gupta	152	Delhi
62	1093	Sh. Sushil Vachani	152	Delhi
62	36033	Sh. Ajay Rastogi	152	U.P.
62	56532	Sh. Harbir Singh Sidhu	152	U.P.
62	3168	Sh. Shreekant Prabhakar Pande	152	Maharashtra
62	4049	Km. Jayshree Shrinivas Yeolekar	152	Maharashtra
69	2098	Sh. Prabir Kumar Datta	151	W B.
69	772	Km. Sheel Bhala	151	Delhi
69	1055	Sh. Ajit Kumar Seth	151	Delhi
69	31067	Km. Nina Kapur	151	U.P.
69	39215	Sh. Anil Kumar Agarwal	151	U P.
74	50788	Sh. Chinmoy Bose	150	W.B.
74	2029	Km. Adelene Jana	150	W.B
74	50055	Km. Uma Bhattacharya	150	W.B.
74	51289	Sh. Ripudaman Malhotra	150	W.B.
74	2806	Sh. Ranjit Kundu	150	W.B.
74	799	Km. Arvinder Kaur	150	Delhi
74	57559	Km. Malini Vijayraghavan	150	Delhi
74	8125	Sh. Rajasekharan M.V.	150	Kerala
74	8151	Sh. T.C. Sundaresan	150	Kerala
74	26341	Km. S. Radha	150	A.P.
84	2526	Sh. Saurendra Nath Konar	149	W.B.
84	790	Km. Vibha Gujral	149	Delhi
84	379	Sh. Vembar Raghu Ram	149	Delhi
84	383	Sh. Komandur Krishnaswamy Sridhar	149	Delhi
84	30881	Km. Rama Agarwal	149	Rajasthan
84	32979	Sh. Ravi V.J. Chari	149	U.P.

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84	32836	Sh. Nilabh Shastri	149	U.P
84	10781	Sh. Krishnan Ganapathy	149	Madras
92	2100	Sh. Debasish Sihi	148	W.B
92	37610	Sh. Abhijit Banerjee	148	Bihar
92	1472	Sh. Arun Kumar Chandrasekhar	148	U P.
92	32778	Km. Perween Kausar	148	Orissa
92	32798	Km Usha Susan George	148	Maharashtra
92	23231	Sh. Manchanahalli Venktaramiah Bhujanga	148	Mysore
98	17698	Km. Geeta Kapoor	147	Rajasthan
98	21650	Sh. Rajat Roy	147	W.B.
98	356	Sh. Rakeshwar Dayal Mathur	147	Delhi
98	30983	Km Rama Padmanabhan	147	Delhi
98	409	Sh. V Seshadri	147	Delhi
98	37607	Sh. Deb Kumar Roy	147	Bihar
98	32976	Sh. V. Srinivasan	147	U.P.
98	15197	Sh. Keshav Dayal	147	M.P
98	52390	Sh T. Rajasekharan	147	Kerala
107	2011	Sh. Narayan Shenoy	146	W.B.
107	386	Km T.R Malathi	146	Delhi
107	505	Sh. S. Yegyaraman	146	Delhi
107	32971	Sh. Ashok Baijal	146	U.P.
107	54822	Sh. Alok Perti	146	U.P.
107	29842	Sh. Krishna Murari Acharya	146	M P.
107	4954	Sh Valanju Prashant Madhusudan	146	Maharashtra
107	36618	Sh. Raghuram	146	Gujarat
107	23050	Sh. Rishyur Sivaswami Nanda	146	Mysore
107	31050	Km. Promila Puri	146	Mysore
117	2006	Sh. Saibal Kumar Saha	145	W.B.
117	2095	Sh. Jayanta Bhattacharjee	145	W.B.
117	50175	Sh. Prodeep Ghosh	145	W.B.
117	742	Km. Madhu Bala Ghildial	145	Delhi
117	32912	Sh. Partha Rakshit	145	Maharashtra
117	9394	Km. Sarah John	145	Kerala
117	22914	Sh Lawrence Packiam	145	Mysore
124	773	Km. Rita Chaudhuri	144	Delhi
124	45425	Km. Shaninder Kaur	144	Delhi
124	32895	Sh. Jayanta Banerjee	144	Bihar
127	2055	Sh. Saibal Kumar Sarkar	143	W B
127	34224	Sh. Dipankar Dutt	143	W.B
127	36002	Sh. Sushil Khanna	143	U.P.
127	3972	Sh. Joshi Girdhar Madhukar	143	Maharashtra
127	22996	Sh. Jacob Richard Fernandes	143	Mysore
132	34296	Sh. Abhijit Mitra	142	W.B.
132	1996	Sh. Partha Basu	142	Delhi
132	775	Km. Divya Rashmi Sharma	142	Delhi
132	43801	Km Gurpreet Kaur Mangat	142	Punjab
136	1478	Sh. Prashant Gupta	141	W.B.
136	56580	Sh. Rakesh Kumar Popli	141	Delhi
136	259	Sh. Vinod Kumar Sapra	141	Delhi
136	1140	Sh. Shubhendu Roy	141	Delhi
136	169	Sh. Jai Narain Gupta	141	Delhi
136	23824	Sh. H. Venkataramana Kedlaya	141	Mysore
136	55035	Km. Ranjana Narula	141	U.P.
136	32738	Sh. Arun Seth	141	U.P.
136	1467	Km. Ratna Banerjee	141	U.P
136	32687	Sh. Vidyasagar Puthran	141	Maharashtra
136	7151	Sh. Sasi Kumar Nair R.	141	Kerala
136	6824	Sh. Deodhar Shripad Shankar	141	Maharashtra
148	32775	Km. Mrinmoyee Chatterjee	140	W B
148	608	Sh. Ashok Gupta	140	Delhi
148	816	Km. Seema Sen Gupta	140	Delhi
148	389	Sh. S. Jagdish	140	Delhi
148	1067	Sh. Omesh Chandra	140	Delhi

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148	6050	Sh Vivek Luther	140	Delhi
148	45411	Sh Sanjeev Saluja	140	Delhi
148	36030	Sh Rajesh Narang	140	U.P
148	20239	Km. Sushma Chaudhry	140	Punjab
148	10062	Sh Prakash Roychoudhury	140	Orissa
148	5058	Sh. Jaco Ookken, V	140	Kerala
148	23099	Km Kathyayini Lingaraju	140	Mysore
148	12888	Sh C Kumar	140	Madras
161	483	Km. Gita Gopalakrishnan	139	Delhi
161	813	Km. Sushma Jindal	139	Delhi
161	39984	Sh Ravindra Kochhar	139	Delhi
161	41476	Sh Jageshwar Swarup Saharia	139	U.P.
161	4807	Sh Ajay Prabhakar Patwardhan	139	Maharashtra
161	5920	Km Shilpa R. Kothari	139	Maharashtra
161	8336	Sh P A Murlidharan	139	Kerala
161	27834	Sh J. Rama Sesha Vidya Sagar	139	A.P
161	23042	Sh. Parvez Habib Taqui	139	Mysore
161	23342	Km. I Kalavathi	139	Mysore
171	506	Km. Rita Nanda	138	Delhi
171	865	Km. Reeta Kohli	138	Delhi
171	17893	Km. Talat Fatima Hasan	138	U.P
171	493	Sh. C.S. Sadasivan	138	Delhi
171	1063	Sh. Vibhor Gupta	138	Delhi
171	32978	Sh Ashok Sajanhar	138	U.P.
171	1575	Sh. Narendra Kumar Pandey	138	U.P..
171	32457	Sh. Nandeibam Rajendra Singh	138	Manipur
171	5299	Km. Sharma Anita Shrikrishna	138	Maharashtra
171	30887	Km Gul Talreja	138	Rajasthan
171	37546	Km. Yasmin Jayathirtha	138	M.P
171	7173	Sh. Leslie Balfour Salem	138	Kerala
171	8995	Km. Geeta Mary P.A	138	Kerala
184	16554	Sh. Rajendra Bhatia	137	Rajasthan
184	504	Sh. K. Thyagarajan	137	Delhi
184	180	Sh. Satish Kumar Goyal	137	Delhi
184	45422	Sh. Jai Rakesh Sharma	137	Delhi
184	43547	Sh. Raman Anantha Narayanan	137	U P.
184	48649	Sh. Rajiv Agarwal	137	U.P
184	15107	Sh. Kannan Kasturi	137	M.P.
184	31011	Sh. Suvesh Chandick	137	M.P.
184	5215	Sh. Panchamatia Ashok	137	Maharashtra
184	8448	Km. Pavana Veeravalli	137	Kerala
184	8086	Sh. P.S. Sugathan	137	Kerala
184	8577	Sh. Alex P. Philip	137	Kerala
184	23260	Km. Rama Devi J	137	Mysore
197	2127	Km. Shyamali Mukerjee	136	West Bengal
197	32753	Km. Atashi Guha	136	U.P.
197	1509	Sh. Atish Adhya	136	West Bengal
197	53624	Sh. Suresh Kaushik	136	Delhi
197	52947	Sh. Rakesh Kapila	136	M.P.
197	672	Sh. Suresh Bajaj	136	Delhi
197	36012	Sh. Bhavaraju Venkata Krishna Keasava Rao	136	U.P.
197	995	Sh. Patnaik Srikrishna	136	Orissa
197	22566	Sh. J. Sriram	136	Mysore
197	4929	Sh. Joseph M. Pinto	136	Maharashtra
197	14209	Sh. Astik Jayaprakash Bhanushanker	136	Gujarat
197	12645	Sh. V.T. Chacko	136	Madras
197	13611	Sh. R. Madhavan	136	Madras
210	2051	Sh. Ajit Kumar Dhar	135	W.B.
210	51411	Sh. Sayan Chatterjee	135	W.B.
210	100	Sh. Sudhir Arora	135	Delhi
210	776	Km. Gogi Nagrath	135	Delhi
210	804	Km. Anjali Grover	135	Delhi
210	905	Sh. V. Nilakant	135	Delhi

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210	1079	Sh. Jyotirmoy Bhattacharjee	135	Delhi
210	1186	Sh Pankaj Mitra	135	Delhi
210	30101	Sh Nand Kishore	135	Delhi
210	30145	Km Reena Ray	135	Delhi
210	31960	Sh. Balwant Singh	135	U P.
210	4806	Sh. Abhyankar, Abhay Hanuman	135	Maharashtra
210	30187	Sh. Rajendra Ramdas Bhinge	135	Rajasthan
210	3976	Sh. Thakoor Anil Kumar Prabhakar	135	Maharashtra
210	4066	Sh. Vaidya Hemant Gajanan	135	Maharashtra
210	23189	Km. L. Shobha Kurup	135	Mysore
210	23015	Sh. N Seshadri	135	Mysore
210	7447	Sh. Kora Ipe, P.	135	Kerala
210	7143	Sh. R Sreekumar	135	Kerala
210	7146	Sh. B. Hari Haran	135	Kerala
230	2057	Sh. Himadri Sekhar Ghosh	134	W.B.
230	30184	Sh. P K. Aravind	134	Rajasthan
230	24958	Sh Jayprokas Chakrabarty	134	W B
230	17906	Km Nilam Walini Kaul	134	U P
230	20240	Km Satinder Aneja	134	Punjab
230	5181	Sh. Uday Ghanashyam Rege	134	Maharashtra
230	490	Sh. P. Krishnamurthy	134	Delhi
230	30139	Sh. Arun Kumar Agarwal	134	Delhi
230	8460	Sh. P.K. Swaminathan	134	Kerala
230	7456	Sh. G. Balasubramonian	134	Kerala
230	1898	Sh. Jatindar Pal Singh	134	H.P
230	22946	Sh. Chandrasekarapuram Venkateswaran Subramaniam	134	Mysore
230	23031	Sh. Francis Placidus D' Mello	134	Mysore
230	10912	Sh. Doss, Kadarundalige Gururaja Radha Mohan	134	Madras
230	1084	Sh Bala Krishna	134	Madras
245	50253	Sh. Avijit Sen	133	W B.
245	2010	Sh. Amitava Ghose	133	W B.
245	2099	Km. Tapashi Chowdhury	133	W.B.
245	50054	Km. Mahamaya Banerjee	133	W.B.
245	50202	Sh. Ashok Kumar Chaudhuri	133	W.B.
245	32977	Sh. Shekhar Agarwal	133	U.P.
245	43572	Sh. Pravin Kumar	133	U.P.
245	32841	Sh. Vijay Kumar Puri	133	U.P.
245	48753	Sh. Shashi Kant Sharma	133	U.P.
245	42078	Sh Narayan Prasad Verma	133	U P.
245	6832	Sh. Patwardhan Dilip Gopal	133	Maharashtra
245	743	Km. Ravinder Kaur	133	Delhi
245	1049	Sh. Dev Kumar Chakravarty	133	Delhi
245	1182	Sh Aditya Kumar Gupta	133	Delhi
245	52960	Sh. Srinivas Rajagopal	133	Mysore
245	8950	Km. G Sathi Devi	133	Kerala
245	30010	Km. Gayatri Krishnanad	133	Kerala
245	22898	Sh. V. Ramesh Venugopal	133	Mysore
245	23032	Sh. Ranjan Mukherjee	133	Mysore
245	12652	Sh. Srinivasan Vijaya Raghavan	133	Madras
245	11797	Km. Geetha Ramakrishnan	133	Madras
266	2020	Sh. Kuo Yang Liu	132	W.B.
266	2184	Sh. Samir Kumar Brahmachari	132	W.B.
266	2242	Sh. Arun Sankar Chowdhury	132	W.B.
266	34172	Sh. Sunanda Banerjee	132	W B.
266	52932	Sh David Preetam Park	132	M P
266	36011	Sh. Pradyut Kumar Mallick	132	U.P
266	744	Km. Jatinder Kaur	132	Delhi
266	801	Km. Sadhana Prakash	132	Delhi
266	461	Sh. V.R.V. Ramanan	132	Delhi
266	481	Sh. K.G. Vijayakrishnan	132	Delhi
266	485	Sh P. Anil Kumar	132	Delhi
266	696	Sh Alok Kumar Mitra	132	Delhi

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266	30104	Sh. Sunil L. Samtani	132	Delhi
266	1113	Sh. Suraj Prakash Seth	132	Delhi
266	7217	Km. I. P. Chandrika	132	Kerala
266	7138	Sh. C. I. Verghese	132	Kerala
266	33753	Sh. Subrata Chakrabarty	132	Assam
266	10777	Sh. S. Kesavan	132	Madras
284	2050	Km. Malti Krishnamurty	131	W.B.
284	34285	Km. Anuradha Das	131	W.B.
284	50185	Sh. Debo Broto Deb	131	W.B.
284	29313	Sh. Shekhar Misra	131	M.P
284	50364	Sh. Sugato Mitra	131	W.B.
284	30489	Sh. Piyush Jain	131	U P
284	50356	Sh. Joy Mukhopadhyay	131	W.B.
284	1465	Km. Chitra Das Gupta	131	U.P.
284	32865	Sh. M. Lingamurthy	131	Delhi
284	653	Sh. Pradip Chakravartti	131	Delhi
284	32665	Km. Raka Srivastava	131	Delhi
284	924	Km. Raj Sharma	131	Delhi
284	30108	Sh. Samirendra Chatterjee	131	Delhi
284	8171	Km. Geetha M.	131	Kerala
284	8985	Km. P. Alamelu Manga	131	Kerala
284	30013	Sh. C. Narasimhan	131	Kerala
284	7445	Sh. P. J. Thomas	131	Kerala
284	14206	Sh. Shah Amit Rasiklal	131	Gujarat
284	32885	Sh. B. Venkat Rama Rao	131	A.P.
284	31653	Sh. Dhotre Balaram Jivraj	131	Mysore
284	22389	Sh. K. S. Dayakar Punja	131	Mysore
284	22403	Sh. R.S. Shreedhra Murthy	131	Mysore
284	57618	Km. Ninu Philip	131	Mysore
284	10782	Sh. Balachander Ganesan	131	Madras
284	10994	Km. Yogambal Srinivasan	131	Madras
309	2094	Sh. Amitava Bose	130	W.B.
309	2102	Sh. Pradip Kumar Chatterjje	130	W.B.
309	21555	Sh. Anup Kumar Ray	130	W.B.
309	50158	Sh. Subrata Sarkar	130	W.B.
309	55030	Km. Kaanan Ratna	130	U.P.
309	36006	Sh. Shantanu Deb	130	U.P.
309	42662	Sh. Bhaskar Sharma	130	U.P.
309	41091	Sh. Rajendra Pant	130	U.P.
309	32672	Sh. Rahaul Kapur	130	Delhi
309	507	Km. S. Lalitha	130	Delhi
309	793	Km. Raka Ukkhal	130	Delhi
309	798	Km. Nandini	130	Delhi
309	814	Km. Renuka Nagpal	130	Delhi
309	1037	Sh. Virendra Kumar Chopra	130	Delhi
309	7159	Sh. P. Rajasekharan Pillai	130	Kerala
309	8087	Sh. Jemmis E.D.	130	Kerala
309	7734	Sh. Babu John P.A. Ulahannan	130	Kerala
309	10751	Sh. Jaithirth Rao	130	Madras
327	6301	Sh. Nehchal Singh Sandhu	129	Maharashtra
327	57744	Km. Basabi Mukherji	129	W.B.
327	2036	Sh. Subrata Saha	129	W.B.
327	34220	Sh. Arvinder Singh Khurana	129	W.B.
327	32972	Sh. Aditya Prakash Murao	129	U.P.
327	43575	Sh. Subodh Chandra Agrawal	129	U.P.
327	827	Km. Jayanti Khosla	129	Delhi
327	354	Sh. Jag Bhushan Bharagava	129	Delhi
327	777	Km. Iqbal Rajinder Kaur	129	Delhi
327	57553	Km. Madhurima Pathak	129	Delhi
327	417	Sh. Rajagoplan Ramanathan	129	Delhi
327	1082	Sh. Sandeep Mathur	129	Delhi
327	1180	Sh. Praveen Mehendru	129	Delhi
327	1188	Sh. Praveen Chaddah	129	Delhi

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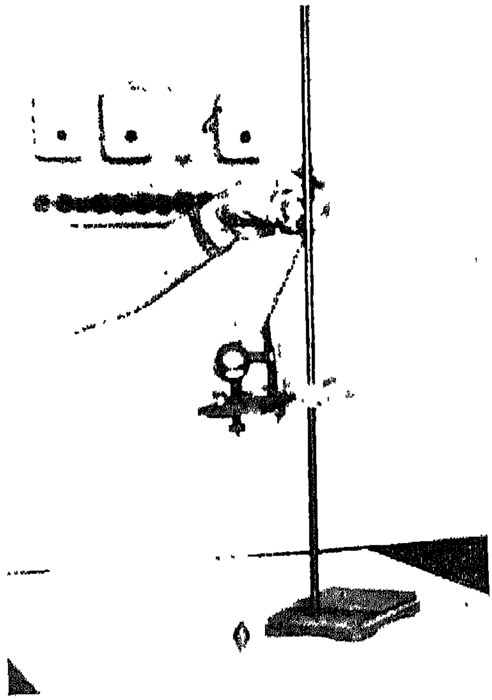
327	1756	Sh. Gurinder Bir Singh Wadhwa	129	Delhi
327	30889	Km. M.K. Lakshmi	129	Rajasthan
327	7457	Sh. P.C. Thomas	129	Kerala
327	22225	Sh. K.R. Anantha Subbaraya	129	Mysore
327	23499	Sh. K. Govindarajan	129	Mysore
327	13965	Sh. S. Ramasubramanian	129	Madras

Letters to the Editor

IN the March, 1968 issue of *School Science*, I read with pleasure an attempt at improvement of the PSSC experiment on the experimental demonstration of conservation of momentum during collision of two balls. I was all the more pleased to find a scientist of the calibre of Prof. B. D. Nagchaudhuri being associated with this work.

I wish to suggest a few "obvious improvements" in the experiment published in that issue of *School Science*. It is possible that the points mentioned below by me are already incorporated in the equipment designed and the experiment performed by the authors But it would have been better if these had been incorporated in the published article as well. Whereas the authors claim to have performed the exepriment with an error of 5 per cent, I have done the same experiment by the PSSC-kit within an error of 1 per cent.



1. It appears from the photograph of the apparatus published by the authors (reproduced here) that the inclined surface used to give the initial velocity to the striking ball is a plane. Thus the initial velocity of this ball at the time of collision appears to be not in a horizontal plane, whereas the collision is supposed to take place in a horizontal plane. Thus it would be better if this surface were curved so that its lower end became horizontal, as is the case when using the plastic scale as the inclined surface while doing the experiment with the P.S.S.C.–kit. In case the inclined surface used by the authors of

the improved experiment had a few centimetres of its length, near the lower end curved so that the striking ball left it with a horizontal velocity, it would have been all right and this suggestion would then have become redundant.

2. It appears that an attempt has been made to equate the vector sum of the velocities of the two balls after collision, with the arithmetic sum of those velocities. The published table to observations seems to indicate this as well as the discussion following it which says "In the above observations the initial velocity of the striking ball before collision can be obtained by simply adding the two vectors and also from the diagonal of a parallelogram formed with the two velocity vectors and the angle of collision."

I think a better way of experimentation would have been to let the striking ball start from the same height every time, and to see whether the vector sum of the velocities of the two balls after collision came out to be the same every time. If a measurement of the initial velocity of the striking ball is desired the experiment may be repeated without the second ball so that the striking ball flies off with the horizontal imparted to it by the inclined surface.

Yours etc.,
VED RATNA

REGARDING the Experiment 6 under "Simple Chemistry Kit" published in June 1967 issue of *School Science*, the following suggestion is made: The use of an open-mouthed test tube as a reaction vessel is highly dangerous. The use of a two-holed stopper with extended exhaust tube eliminates this hazard.

Yours etc.,
P. S. V. RAO

EDITORIAL

As one of the steps towards giving our readers a more punctual *School Science*, we decided to combine the September 1968 and December 1968 issues. Our justification for this measure is that it takes us nearer to fulfilling the assurance offered in our last issue that the journal would be more regular in future. We expect that this combined issue will give readers the same satisfaction that the two separate issues would have.

The contents of this number range from a most informative article (B. J. Heywood *The Continuing Struggle against Weeds*) on the latest herbicides for combating different types of weeds to a discussion (A. A. Gurshtein, *Probing The Secrets of the Solar System*) of the observations of the atmosphere of Venus from data obtained by Russian space vehicles during 1961-65. N. K. Verma in *Two Foundation Stones of Radiation Medicine* gives an account of the discovery and applications of X-rays and radium. Y. A. Naumov and B. D. Atreya in *The Nature of Organic Compounds* discuss the typical features of organic compounds and bring out how they are different from inorganic compounds. Secondary school students will find this article very useful in clarifying their ideas and concepts on this subject; the authors have also given biographical notes on Berzelius, Wohler and other chemists who have contributed notably to the development of organic chemistry. In *A Physical Principle – Paradoxical but Fundamental*, Chhotan Singh discusses Schrodinger's 'wave equation' and Heisenberg's 'uncertainty principle' in quantum mechanics, this discussion will be of special interest to teachers and the more advanced students.

There are two other articles which would greatly interest all readers. In *Air to the Rescue*, James Lawrie describes how the hovercraft principle can be applied in lifting and moving heavy loads in industry, while in *Were the Planets Hot from the Start*, the author discusses the theory put forward by Fred Hoyle and N. C. Wickramasinghe that the earth and other planets were made hot and have cooled down since.

Coming to the regular features, under *Classroom Experiments*, Ved Ratna does some re-thinking on the experiments usually chosen to demonstrate that the thermal conductivities of different substances differ. In *Science Abroad*

we have an account of a new experiment in science teaching — the teaching of 'environmental science' — being carried on in New South Wales, Australia. There are also two articles on the Nuffield Foundation Science Teaching Project.

In *Young Folks Corner* and *Science Notes* we have a variety of useful information regarding te latest developments in the various fields in science. In other features there are same interesting reports about the Summer Institutes in Science held during 1968 and the latest news regarding the Science and Mathematics Teaching Project.

Apart from the regular features, we believe readers will note with interest two letters to the Editor which comment on the experiment to demonstrate the conservation of momentum (*School Science*, March 1968) and on the Simple Chemistry Kit described in *School Science*, June 1967.

And, last but not least, we carry under *News and Notes* the summarized recommendations of the CASTASIA Conference held in 1968 in New Delhi.

Two Foundation Stones of Radiation Medicine

N. K. VERMA

Institute of Nuclear Medicine and Allied Sciences

MODERN physics may be said to date from 1895 when Roentgen discovered X-rays. Two other major discoveries followed in quick succession, namely the discovery of radio-activity by Becquerel in 1896 and the discovery of radium by Madam Curie in 1898. These epoch making discoveries not only revolutionised physics but have proved to be of immense application in the medical field.

Madam Curie's birth centenary was recently celebrated in Nov., 1967. This article gives an account of the discovery and applications of the two foundation stones of radiation medicine, namely X-rays and radium.

The first Nobel Prize for physics was awarded to Wilhelm Conrad Roentgen, Professor of Physics and Director of the Physical Institute of Wurzburg in Bavaria, for his epoch-making discovery of X-rays on 8 November 1895. He saw the bones of his living hand projected on a barium cyanide screen when he interposed it between the invisible beam of electromagnetic radiation, originating from the Hittorf-Crookes tube, excited under the influence of high voltage from an

WILHELM CONRAD ROENTGEN
Winner of first Nobel Prize for Physics, **1901**, (*Courtesy*: Dr. LEWIS E. ETTER *and the Science of Ionizing Radiation*)

induction coil, and the detector plate. And this was the beginning of Radiation Medicine.

He made two important communications in this connection. The first

was on 23 January 1896 in the auditorium of the Physical Institute. The title of his lecture was: "A New Kind of Ray (Ueber eine neue Art Von Strahlen)" in which he explained about his discovery of the penetrating rays. His lecture was accompanied by demonstrations. He took the X-ray photograph of the hand of Von Kolliker, the famous anatomist of the Wurzburg University and he showed it to the audience. In his second communication on 10 March 1896, he explained the various properties of this new kind of ray. This was entitled "Further observations on the properties of X-rays".

These two communications of far reaching importance were sufficient to stimulate, originate and develop a number of new ideas and researches. This physical discovery, in its further developments, led to an integral discipline of physics, general science, engineering, biology, medicine, chemistry, mathematics and so on; and it entered the field of almost any and every subject. It also helped to explain many phenomena hitherto regarded as unsolved mysteries of nature.

Roentgen died of cancer of the intestine on 10 February 1923 in his Munich residence. He however impregnated his dynamic image over his time, which, like engravings on stone, can be seen in hospitals, research laboratories, biological laboratories and analytical institutions all over the world.

Within a matter of months, this discovery caught the imagination of scientists all over the world. Medical and commercial applications of X-rays followed with great rapidity. Speaking

A.H. BECQUEREL.
Winner of Nobel Prize for Physics 1903,
(Courtesy: Prof. A. Gandy, Foundation Curie, Paris).

exactly, it was after one month and three days only of the discovery of X-ray that it was brought into use in Belgium hospitals. Roentgen Societies and Committees came into existence. Scientists and engineers put their heads together for the development of X-ray apparatus. Film manufacturers and dark room technicians made themselves busy after X-ray applications for the purposes of diagnosis. The subject of X-rays formed a strong nucleus round which many other branches of science began to revolve.

Before this discovery, hospitals were acquainted with the application of electromagnetic energy in the form of high frequency current, diathermy, etc. but it was for the first time that this energy

(electromagnetic) entered the arena for the hospital in the form of penetrating radiation. Both civil and military uses of X-rays were quickly realised.

But not even six months had passed before reports of dermatitis on the hands of X-ray workers were received. These were similar to those which appeared before 1895, on the hands of discharge tube and vaccuum tube workers, resembling sun-burn. This proved that X-rays could induce biological changes. And so, it was the starting point of radiation plus biology, that is radio-biology.

And now, with the help of X-rays, supported by special radiographic procedures, about two dozens of radiographies, covering from head to foot, are possible. Medical examinations of, say, neck section, chest, breast, cardiovascular system, genitourinary tract, skeleton, lymphatic system etc can routinely be carried by means of X-radiation.

X-rays also began to be used for the treatment of tumours. In the field of kilovoltage and supervoltage therapy, 250 kv, 400 kv, million volt and two million volt X-ray machines are quite popular. Even in a linear accelerator or in a van de Graaf generator or in a betatron, high energy electron beams are sometimes hurled against a target to produce highly penetrating X-rays, which in turn, are made useful, in the treatment of deep-seated tumours.

Thus roentgenography and radiobiology have become established as recognized specialities in clinical medicine. This was the first foundation stone of radiation medicine.

The second important phase followed in quick succession. It happened thus. Aroused by this sensational discovery of X-ray, Antoine Henri Bacquerel, the son of a professor of physics in Paris, began to look for a similar sort of penetrating ray from some other source. He thought about the phenomena of fluorescence which was seen to occur inside the Hittorf tube at the point where cathode rays struck the wall of the tube to originate X-radiation. The suggestion, therefore, was that there must be some sort of correlation between the fluorescence and the emission of X-ray. It could be possible that the substance, capable of giving rise to fluorescence or phosphorescence could also be the emitter of this X-radiation. Driven by this belief he began to examine a number of such substances. In that pursuit he undertook the investigations of double sulphate of uranium and potassium. He also used photographic film as the detector of radiation. He found that the film, wrapped up with black paper, over which the crystal of uranium salt was kept in the drawer of his table, because of cloudy weather, for several days, showed the image of the substance on its developing. This photograph was similar to the one which he had obtained when the same arrangement of crystal and the photographic plate was kept in the sunshine. Rays, similar to X-ray, had thus been discovered by Becquerel. He found that, this emission was inherent in all the uranium compounds. Fluorescence had nothing to do with it. Becquerel communicated the result of his investigations to the Academy of Science, Paris, in the month of January 1896, that is only after three months of the discovery

of X-rays. This was the beginning of natural radioactivity.

At this stage, Marie Sklodowska, a Polish girl, the daughter of physicist parents, holder of masters' degrees in physics and mathematics, a research scholar and the wife of a celebrated scientist Pierre Curie of Paris, was attracted by Becquerel's radiation. She began to investigate all the available substances for their emission of any penetrating radiation. In her case the

Prof. PIERRE CURIE *and his wife* MARIE SKLODOWSKA Curie.
(*Courtesy: Prof. A. Gandv, Foundation Curie, Paris*).

detector was not a photographic film but a device based on the principle of ionization. The ionization chamber coupled with an electrometer, working on the principle of piezoelectric effect of quartz crystals, discovered by her husband, measured the intensity of radiation coming from the sample. Every time she found that the intensity was proportional to the amount of sample under investigation. A preparation of thorium salt also gave the same sort of result. But chalkolite, a uranium mineral, showed higher intensity than what was expected. She concluded that there must be a substance other than uranium, present in the sample, responsible for the higher emision. It really came out to be so when she started her historical work in collaboration with her husband, in the hutment of a school. The hard work of days and nights consisted of pulverization, precipitation and fractional crystalization of pitchblende ore from the JOACHIMSTHAL uranium mine in Bohemia. The processing of each twentyfive pounds of ore gave an yield of a milligram of a white shining metal which was announced in December 1898 as radium. This new substance was two million times more active than uranium. The name radioactivity, that is, action at a distance, was given by Mme Curie to all those substances which emitted radiation. Thus came into existence an element which is playing a vital role in clinics and in laboratories, even to day.

In the year 1903, Mme Curie submitted her thesis for her degree of doctorate in which she described the various properties of radium.

She was the recipient of the Nobel Prize for physics jointly with A.H. Becquerel in 1903. She received the Nobel Prize for the second time in the year 1911, this time for chemistry.

Biological and medical implications of radium came accidentally when in 1901

MARIE CURIE
Nobel Prize Winner for Physics 1903, *for Chemistry* 1911
(Courtesy: Prof. A. Gandy, Foundation Curie, Paris).

Becquerel loaned some radium from the Curies for a demonstration to his students. A glass vial containing 200 milligram of radium remained in the pocket of his vest coat for six hours. This produced erythema that is reddening of his skin just beneath the vest coat pocket. Then appeared crackings of the skin at that site finally forming into an ulcer which was painful. Conventional treatment was able to bring a cure.

On receiving this report, Pierre Curie voluntarily exposed his arm to the rays from radium to verify the findings and he went through the same experience as substances like radium were also capable of producing biological changes just as X-ray did. The Curies and Becquerel started a lot of animal experimentation to study the physiological effects of radium rays. During years 1901–1906 radium was tried for its therapeutic effects on a number of ailments such as blindness, dermatological conditions, sciatic pain, female hemorrhages, cancer etc.

Then in the year 1906, the Biological Laboratory of Radium (which later on became Foundation Curie) came into existence in Paris and it started clinical works with radium. This was followed by radium institutes and radium departments in other countries also. Similar to X-rays, this discovery too spread far and wide and secured its position in the clinics.

Mme Curie, a lady of great eminence, the symbol of scientific faith and missionary zeal, a deep devotee at the temple of learning, did phenomenal work during her life time. Perhaps nature itself became jealous of her achievements, honours and awards. She became a widow when her illustrious husband Pierre Curie was run over by a truck on 19 April 1906. Soon after this tragic event however, she was again deeply engrossed in her work. As a result of prolonged exposure to anaemia she died of it on 4 July 1934. Radium which had bestowed such incalculable gifts in the alleviation of disease, took its toll from its discoverer. Mme Curie left behind her, an ideal and a strong scientific legacy in the persons of her daughter, Irene Curie and her son-in-law, Prof. Frederic Joliot Curie, again both of them Nobel laureates.

Rapid research and development followed and radium was found to be best suited for cancer treatment. Inter stitial, intracavitary and surface applica-

Prof. FREDERIC JOLIOT CURIE *and his wife* Mme IRENE CURIE (*daughter of Mme Curie*) *Centre of the photograph.*
Winners of Nobel Prize for Chemistry, 1935. (*Courtesy: Prof. A. Gandy, Foundation Curie, Paris*)

tors of radium in the form of moulds, plaques, etc came into use for the treatment of cancer of the various regions of the body such as skin, hand, nose, ear, eye, tongue, oral cavity, vocal cord, breast, uterus, rectum, etc. Permanent implants of radon seeds (bits of thin gold tubing containing radon gas) at certain delicate sites like tongue, tonsil intestine etc. proved to be very effective. Combined therapy of surgery and radium, backed up by roentgenography gave excellent results. Radium packings on curie level, gave high intensity beams of gamma radiation suitable for the treatment of deepseated tumours. Solid radium salt filled in platinum containers in the shape of needles and shells began to pour into the hospitals. In our country, this costly substance (about Rs. one lakh for a gram) came for the first time in Ranchi, Bihar, around the year 1920.

Thus the two great discoveries of X-ray and radium plus the pioneering work of Roentgen, Becquerel and Mme Curie laid the foundation stones of Radiation Medicine.

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The Nature of Organic Compounds

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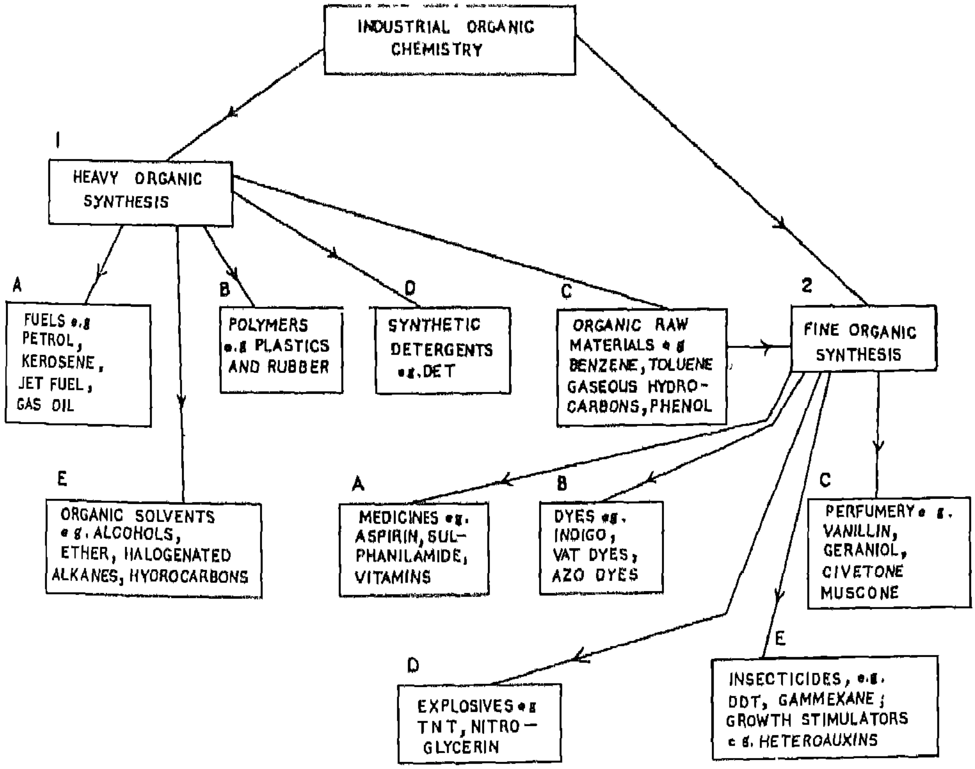
IT is difficult to enumerate all the organic substances, which are being produced in industry today. Many people have started calling the twentieth century as 'The century of atom and polymers.' According to calculation of experts, different polymers will compose about 50% of all the materials used in mechanical engineering by the year 1980. Even at present, in a modern airliner, there are about 120,000 parts made of plastics and rubbers. The main fields of industrial organic chemistry have been shown in a tabular form.

The industry of heavy organic synthesis (column 1 in the Table) is producing some important substances in large amount (polymers, petrol, alcohol,

TABLE — I



acetic acid etc). In the case of fine organic synthesis (Column 2 in the Table) the production is not so large. Examples of fine organic synthesis are medicines, perfumery and dyes etc.

It is important to mention here that all fine organic synthesis is based on organic raw materials obtained by heavy organic synthesis. Moreover, some important inorganic products (e.g., hydrochloric acid, hydrogen) are also produced as by-product of organic synthesis.

The above chart shows the tremendous importance of organic chemistry for the growth of national economy. Moreover, it also explains the rapid development of industrial organic chemistry.

The term Organic Chemistry was introduced in 1807 by Berzelius[1]. It was associated with the wrong idea, that organic substances could be formed only in living organisms. It was called *vitalistic* theory (in Latin vita means life). This theory postulated that all organic substances could be formed only in living organisms under the influence of a special agency called 'vital force.'

In 1828 Wohler, a student of Berzelius, synthesised urea (a product of metabolism in living organisms) from inorganic substances.

Though the concept of 'Vital Force' was thus proved to be wrong, it took quite some time for the contemporary chemists to discard it. However, the term Organic Chemistry continues to be in use even now.

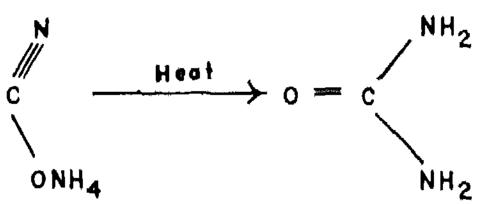


Fig. 1

Many attempts were made to define the characteristics of organic substances. In 1889 Schorlemmer proposed a definition of organic chemistry that is widely used now-a-days.

> *Organic Chemistry is the chemistry of hydrocarbons and their derivatives*

In spite of all attempts to define Organic Chemistry and organic substances, no sharp boundary can be drawn even now between inorganic and organic substances. Yet there are some reasons for treating organic compounds as a special class.

1. One of the main reasons for still regarding organic compounds as an individual group is their unusually large number. At present the number of organic substances has reached about four millions, whereas there are only about 200,000 inorganic compounds. The carbon-carbon covalent bond in the compounds of the general formula $CH_3-(CH_2)$ n–2–CH_3 is very stable. For example, the hydrocarbon (polyethylene) consisting of about 1000 carbon atoms (n=1000) has been prepared. In contrast to this, the maximum number of silicon atoms in a stable compound of the general formula $SiH_3-(SiH_2)n-2$ SiH_3 is only six (n=6). It is all the more surprising since silicon is the closest neighbour of carbon in the Group IV of the Periodic Table.

2. A large number of organic compounds is not stable to heat at or above 300–400°C, whereas most of the inorganic ones are quite stable in this temperature range. It is easy to demonst-

rate, for example, that while sugar and starch char on heating, common salt and caustic soda do not decompose under same conditions.

3. The structure of most organic compounds is more complex than that of a majority of inorganic ones. For example, the molecular weight of polyethylene is about 10,000 while the molecular weight of most inorganic compounds is much less.

4. The speed of organic reactions is in general much less than that of the ionic reactions of inorganic substances. A very simple example illustrates the differences.

$$\underset{\text{Alcoholic solution}}{AgNO_3} + \underset{\text{Sodium chloride}}{NaCl} \xrightarrow{\text{Fast}} AgCl\downarrow + NaNO_3$$

$$\underset{\text{Alcoholic solution}}{AgNO_3} + \underset{\text{Ethyl bromide}}{C_2H_5Br} \xrightarrow{\text{Slow}} AgBr\downarrow + C_2H_5NO_3$$

Fig. 2

Besides a difference in the reaction rate, most organic reactions differ from inorganic ones in that they proceed simultaneously in a number of ways forming different products. For example, in the reaction shown below:

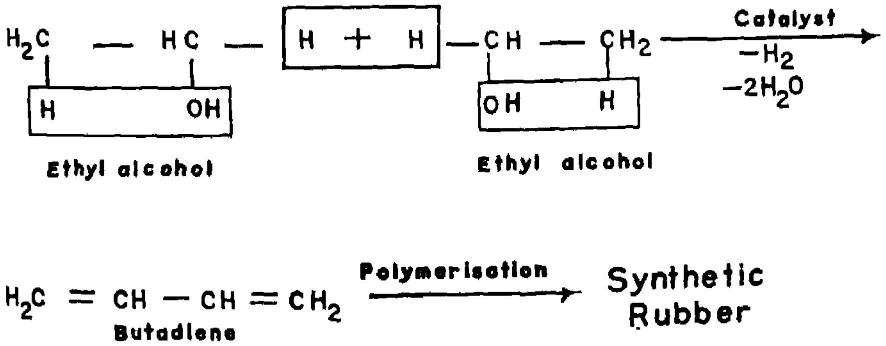


Fig. 3

The yield of butadiene is only about 50%. The reason is that alcohol takes part in other transformations at the same time. Here are two such changes:

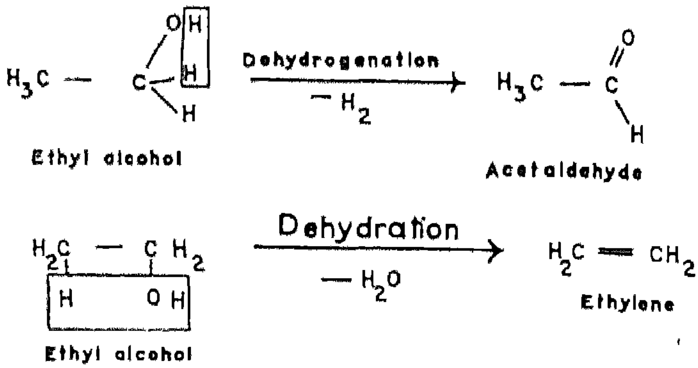


Fig. 4

If the yield of organic product is even 50 to 80% of the theory, it is considered as satisfactory in most cases.

Let us now consider some of the main theoretical concepts of Organic Chemistry.

Organic substances like alcohol, vinegar, natural dyes had been known for a very long time. The development of theoretical concepts about the nature of organic compounds, however, started only at the middle of the 19th century. Here are some most important steps in this development.

A. In 1857, Kekule and Kolbe stated that the valency of carbon is always four.

B. In 1857, Kekule and Couper independently drew attention to the fact that carbon atoms have capacity to link with one another to form long chains.

C. In 1861, Butlerov stated the theory of chemical structure of organic substances. This theory is the basis of modern theory of organic chemistry.

The main points of the modern theory of organic chemistry are:

(a) The concept of chemical structure which includes:

(i) The nature of atoms which compose the molecule;

(ii) The order of their bonding;

(iii) the nature of the bonds.

(b) The properties of a substance depend upon its chemical structure. In other words the formula of a substance expresses not only its chemical structure but also some of its properties.

(c) The chemical properties of individual atoms in the molecule depend upon the nature of other atoms (the concept of mutual influence of atoms).

The following examples illustrate the above points of the modern theory of organic chemistry.

1. Here are the formulae of three different oxides—SO_2, CO_2, SiO_2., These oxides are built from oxygen and an atom that is different in each case. So they have different structures and because of their different structures they have different properties.

2. The molecular formula of butane is C_4H_{10}. This formula indicates that a molecule of butane is composed of 4C atoms and 10 H atoms. Theoretically two structural formulae can be written corresponding to the above molecular formula. One can write these structural formulae by starting from the structural formula of propane and then replacing an H atom with CH_3 group.

The properties of iso-butane differ from the properties of normal butane due to difference in order of bonding of carbon atoms In this case the different order of bonding leads to differences in properties (B.P. density, chemical properties etc.)

The example of the two butanes will now be used to illustrate another important feature of organic compounds.

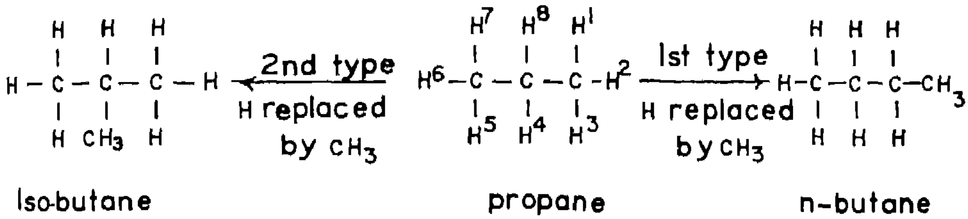


Fig. 5

There are two types of H atoms in the propane molecule.
H atoms (1, 2, 3 and 5, 6, 7) attached to the two primary carbon atoms are of the first type and H atoms (4, 8) attached to the secondary carbon atom are of the second type.

Correspondingly, the replacement of H atom (any of 1, 2, 3, 5, 6, 7,) would give one type of butane (n-butane), and the replacement of another H atom (either 4, or 8) would give another type of butane (isobutane). Both these isomers are known.

This is isomerism. Both n-butane and iso-butane have the same molecular formula C_4H_{10} and yet they have different properties. They are isomers of butane.

Isomers are substances, having the same molecular formula, the same molecular weight, but different structures and properties.

There are different kinds of isomerism such as: (a) Skeleton or chain isomerism e.g. n-butane, isobutane (refer to formulae in Fig. 5)

(b) Isomerism based on the position of the functional group. (fig. 6)

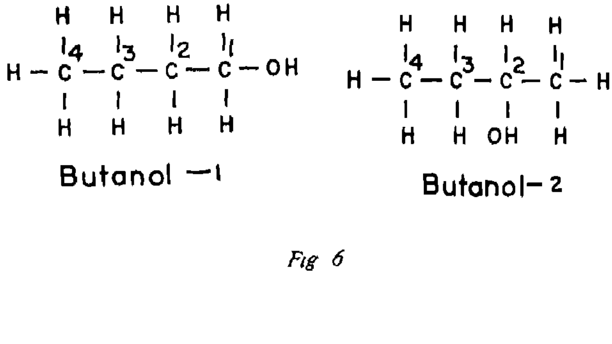


Fig 6

(c) Isomerism based on the position of multiple bond (fig. 7)

Fig. 7

3. Comparing the formulae of ethane and ethylene one can see, that a difference in the nature of bonds leads to a difference in the properties. For

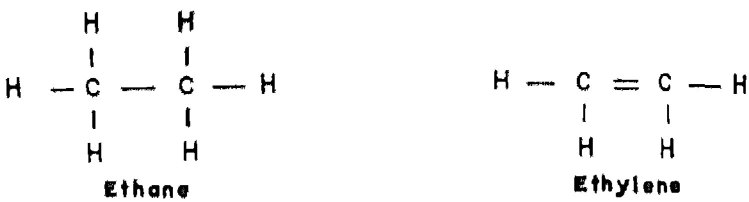


Fig 8

instance, thylene reacts with bromine water very easily. In contrast to ethylene, ethane does not react with bromine under the above conditions. Substances like ethane are called "saturated" hydrocarbons.

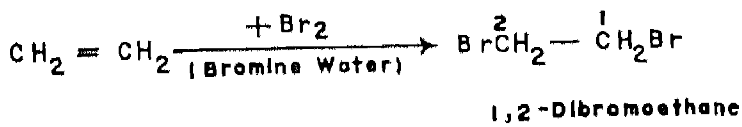


Fig 9

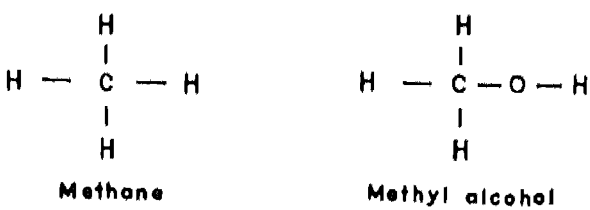


Fig. 10

4. Let us compare the following substances. (Fig. 10)

In methane all hydrogen atoms are directly linked with the carbon atom. In the case of methyl alcohol only three hydrogen atoms are bonded with the carbon atom directly. The fourth one is connected with the carbon atom only indirectly through the oxygen atom. It means that in methyl alcohol these two types of hydrogen atoms should have different properties. In fact one can accomplish the following reaction rather easily with methyl alcohol:

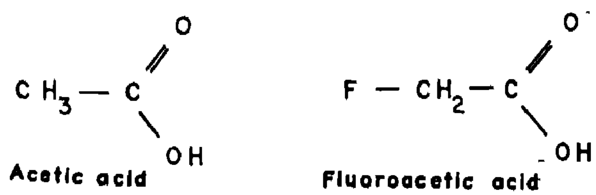
$$2CH_3OH+2Na \rightarrow 2CH_3ONa+H_2$$

Methane, on the other hand, does not react with metallic sodium under the same conditions.

5. The concept of mutual influence of atoms is well illustrated by the following example:

Acetic acid is a weak acid with a dissociation constant $=1{\cdot}76\times10^{-5}$

The dissociation constant of fluoroacetic acid, on the other hand, is 220×10^{-5} The much enhanced strength of fluoroacetic acid is due to the influence of the fluorine atom. (Fig. 11)



$$K_D \times 10^5 = 1{\cdot}76 \qquad K_D \times 10^5 = 220$$

Fig. 11

Earlier it has been mentioned that one of the reasons for the existence of a large number of organic compounds is a high stability of the C–C covalent bonds. Let us now consider why this bond is so stable.

The unusual stability of the inert gases is well known. This stability is due to the structure of their outermost shells. All inert gases have eight electrons in the outermost shell. Only one of them–helium, has two electrons in the outermost shell.

Let us compare the electronic configurations of the outermost shells of helium (I) and neon (III) with the electronic structure of ethane (II) for instance: (Fig. 12)

From this scheme one is led to conclude that the C–C bond should be quite stable because both atoms of carbon are surrounded by an electron octet.

At the same time the C–H bond should also be strong because electronic structures of both the carbon and the hydrogen atoms resemble electronic structures of neon and helium respectively.

Another important feature of organic compounds depends upon their spatial

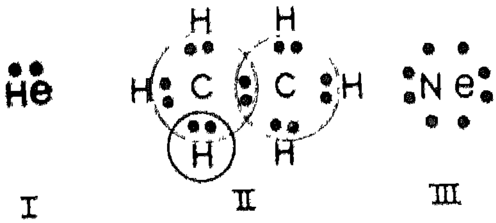


Fig. 12

configuration. Let us take up methane as an example and consider how it can be represented by a formula:

(a) CH_4: This is the so-called condensed structural formula of methane. It is also its molecular formula. Very often methane is represented by the following more elaborate formulae:

(b) Electronic formulae

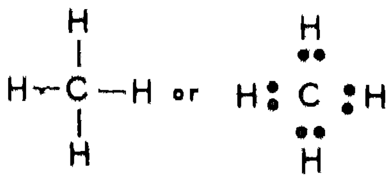


Fig. 13

The spatial configuration of methane may be represented as in Fig. 14.

The bond angle HCH is equal to 109°28'. Under the above angular conditions in methane molecule, the atoms of hydrogen exert least possible influences upon one another. Homologues of methane also have the same values of bond angles. For instance, the carbon skeleton of n-butane is represented as follows:

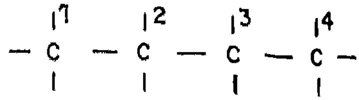


Fig. 15a

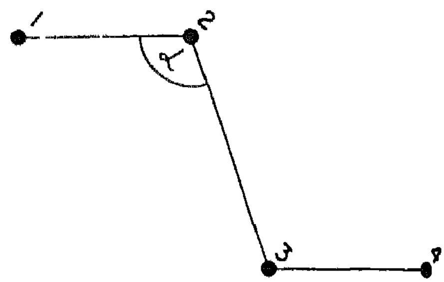


Fig. 15b

Bond angle α is approximately equal to 109°.

X-ray analysis has shown that the distance between the centers of C and H atoms in the bond C–H (let this distance be r) is less than the sum of the radii of C atom (r_C) and H-atom (r_H) Thus one can write mathematically

$$r < r_C + r_H$$

Fig. 16

It seems that the common pair of electrons draws the centers of C and H atoms nearer to one another.

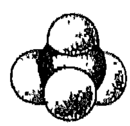


Fig. 17

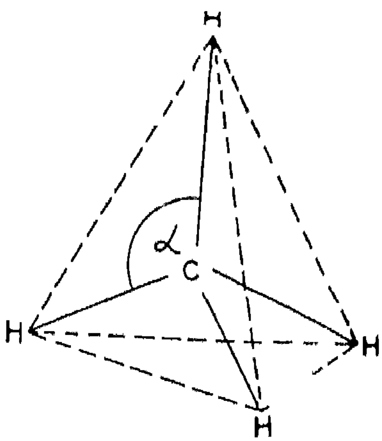


Fig. 14

In conclusion it may be stressed that it is not possible to throw light on all problems of structure of organic compounds in a short article like this. It is a rapidly growing research frontier of organic chemistry which is still engaging the attention of top-most organic chemists.

Biographical Notes on Berzelius, Wohler, Kekule, Kolbe, Couper, Butlerow and Schorlemmer

1. **Jons Jacob Berzelius** (born 20 August, 1779 in Vaversunda, Sweden, died 7 August 1848 in Stockholm). His parents died when he was young Berzelius was brought up by his step father. At the age of 17 he left the school. The headmaster reported about Berzelius that there was 'little hope for him'. In spite of this poor opinion, he graduated from Uppsala University with a dissertation on 'mineral water'. At the age of 23 he received his M.D on a thesis on medical applications of galvanism.

At the age of 28 Berzelius was appointed Professor of Medicine and Pharmacy in the School of Surgery in Stockholm A year later he was elected a member of the Swedish Academy of Sciences. Ten years later, at the age of 39 he rose to the rank of a Joint Secretary of this academic body

Berzelius's main aim in all his experiments was to find support for Dalton's atomic theory and his own electrochemical theory. According to Wohler, Berzelius's Laboratory consisted of 2 rooms without furnaces, fuels, water or gas. In this modest laboratory Berzelius invented many types of apparatus (e.g. retort' stand with rings, triangle support for crucibles, glass spirit lamp, screw clamp, wash bottle with a single tube) which were later on accepted as if existing from the earliest beginnings of experimentation in science.

In spite of the poor laboratory conditions his experimental work covered wide areas in chemistry. He published over 200 papers and notes.

Berzelius was a great systematizer in chemistry. His dualistic (electrochemical) theory about the nature of compounds helped to co-ordinate a large number of facts in chemistry. Berzelius was slow thinker—which was probably necessary for systematization Wohler says that Berzelius on seeing a hasty experiment would remark 'Doctor, that was quick but bad'.

2 **Friedrich Wohler** (born 31 July 1800 in Eschersheim near Frankfurt in Germany-died 23 September 1882 in Gottingen) was the son of a veterinary surgeon. In 1823, he took a medical degree but decided to be a chemist. It is said that Wohler never attended a formal course in Chemistry in his life. In 1823-24 he spent about a year with Berzelius in Stockholm In 1825 he became a teacher in a Berlin Technical School In 1835, he visited England and met Faraday who thought he was meeting Wohler's son, because of his youthful appearance.

On 22 February 1828, Wohler wrote to Berzelius saying 'I can make urea without the necessity of a kidney or even of an animal, whether man or dog'

Liebig regarded the discovery of Wohler as 'the first beginnings of a truly scientific Organic Chemistry' Commenting on the effect of this discovery Kolbe wrote. 'the natural barrier which until then separated the organic from the inorganic compounds had fallen, and a classification of chemical compounds into organic and inorganic in the earlier sense had no natural basis.

3. **Friedrich August Kekule** (born 7 September 1829 at Darmstadt in Germany and died 13 July 1896 in Bonn) studied, in 1847, architecture since he was talented in drawing and mathematics. The influence of Liebig (1848-51) drew him to chemistry which he studied in Paris (1851-52). While in London (1854-55) as a research assistant he brought out his structural theory of molecular architecture.

Kekule later said that the idea of the

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1 From **A History of Chemistry**, Vol. 4, by J. R. Partington

linkage of carbon atoms occurred to him on the top of a London omnibus on a summer evening in 1854 Here is his description of the event:

'I fell into a reverie. The atoms were gambolling before my eyes. I had always seen them in motion, these small beings, but I had never succeeded in discovering the nature of their motion Now, however I saw how, frequently, two smaller atoms united to form a pair, how a larger one embraced two smaller ones, how a still larger one kept hold of three or even four of the smaller; whilst the whole kept whirling in a giddy dance. I saw how the larger ones formed a chain and the smaller ones hung on only at the end of the chain'.

He was awakened by the call of the omnibus conductor and spent part of the night putting sketches of the dream pictures on paper: "So arose the structure theory".

4. **Hermann Kolbe** (born 27 September 1818 near Gottingen, Germany, died 25 November 1884 near Leipzig, Germany). He was eldest of the 15 children of a Lutheran pastor. At the age of 20 he studied under Wohler, and worked as an assistant to Bunsen when he was twenty four. He succeded Bunsen as Professor at Marburg in 1851.

Kolbe was an outstanding experimenter and also a very successful teacher. His text-books are very well-arranged. Kolbe was very critical of using loose and ambiguous expressions in scientific papers.

Kolbe was a pupil of Bunsen and a follower of the views of Berzelius. Kolbe was a straight-forward and fearless man. He never failed to express his opinions even if it opposed those in authority. Throughout the period of the development of the 'Type Theory' by Wurtz, Kekule and others, he vehemently opposed it.

5 **Archibald Scott Couper** (born 31 March 1831 and died 11 March 1892) studied in Edinburgh in his early years, and later with Wurtz in Paris He returned in 1858 to Edinbugh as an assistant In 1859 his mind gave way and he never fully recovered

Couper held that carbon has two highly distinctive properties (i) it combines with equal number of equivalents of hydrogen, chlorine, oxygen, sulphur etc. and (ii) it enters into chemical union with itself Couper said 'These two properties in my opinion explain all that is characteristic of Organic Chemistry. The second property is, so far as I am aware been signalised for the first time'

6. **Alexander Michairlovich Butlerow** (born 6 September 1829 and died 17 August 1886) studied under Zinin but was essentially self-taught He was Professor in Kazan (1852) and St. Petersburg 1868).

He proposed the term 'Chemical structure' (chemische struktur) in place of 'constitution' suggested by Gerhardt. He assumed the tetrahedral arrangement of carbon valencies.

He proposed the law: **Two molecules with the same empirical formula are identical when the chemical relation of every single atom to other elements (not to definite elementary atoms) is the same.**

7. **Carl Schorlemmer** (born 30 September 1834 at Darmstadt and died 27 June 1892 in Manchester) after studying pharmacy at Heidelberg went to Giessen in 1859 where he studied chemistry. Later, he became Rosco's assistant in Owens College Manchester and in 1874 became Professor of Organic Chemistry there—the first chair of its kind in England. This chair he occupied until his death

Here are two different reactions to Schorlemmer as a teacher.

Kipping said 'Schorlemmer read his lectures without emphasis or pause from notes held close to his nose' but Smithells said 'they were an awakening to the genuine student'.

A Physical Principle – Paradoxical but Fundamental

CHHOTAN SINGH
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DE BROGLIE'S hypothesis of matter waves was the starting point for a new theory called "wave mechanics," which resolved the *wave particle* discrepancy.

Erwin Schrodinger developed the hypothesis of matter waves into a general and precise theory for the description of particle motion. He put the hypothesis in mathematical form by developing a "wave equation" of the type, $\frac{d^2\psi}{dx^2}+\frac{2m}{x^2}(E-V)\psi=0$ This is a complicated differential equation. Besides other quantities, it also includes a quantity ψ (psi) which corresponds to the amplitude of ordinary waves. In general, the solution of any problem involves solving the wave equation for ψ at the particular place and time. A question immediately arises: What is the physical significance of the quantity ψ ? Max Born's interpretation is that the value of ψ at any place determines the *probability of finding* the particle there.

The idea of probability is not new in physical science. We first encounter it in our study of the kinetic theory of matter where we talk about the most probable and average velocities rather than the velocity of one particular molecule. The idea of probability is also central in our discussions of reaction rates, both chemical and nuclear. Before the advent of wave mechanics, however, this need to talk of probability was considered to be due primarily to our deficiency in observation rather than to a fundamental principle. In accordance with Newtonian mechanics it was thought that with sufficiently precise methods, the motion and position of any particle could be observed exactly. Wave mechanics, on the other hand, does not make this claim of exactness in such measurements in spite of the best sophistication in instruments and techniques of measurement. This stand of the wave mechanics, gave birth to a fundamental physical principle of quantum mechanics. It is known as the uncertainty principle. It was enunciated by Werner Heisenberg in 1927. It states that pairs of cannonically canjugate variables exist in physics which have an ultimate error imposed jointly

upon their determined values. The most common pairs of conjugate variables of such type are (a) position, x and momentum, p and (b) energy E and time t. These conjugate variables are connected quantitatively by the uncertainty principle as, $\Delta p_x \cdot \Delta x \simeq h$ and $\Delta E \cdot \Delta t \simeq h$ Here, Δp_x and Δx are the simultaneous uncertainties in p_x and x. Similarly ΔE Δt are the simultaneous uncertainties in the measurement of E and t where as h is planck's constant $h = 6{\cdot}62 \times 10^{-34}$ joules sec.

It is evident that the uncertainty principle is stated in terms of a product of uncertainties, which is of the order of Planck's constant, h. The error imposed is thus a joint, or reciprocal property of the two variables taken together. For example, one can make an indefinitely accurate measurement of momentum but such a measurement would imply correspondingly large uncertainty in the measurement of the position of the particle.

An important feature of the uncertainty principle is that it is indeed a principle of physics and has nothing to do with the details of experimental apparatus. For any real experimental measurement, of course, the crudity of the measuring instrument gives rise to a range of error in the measurement. For example, in weighing an object, friction in the bearings of the balance imposes a limit on the sensitivity of the balance. Similarly, in the case of measuring length, the measurement can not be made more accurate beyond a certain limit dependent upon the fineness of the scale divisions. However, this type of error, can be improved upon by building better measuring devices. In principles, one can always imagine an apparatus in classical physics, which can make measurement to any finite accuracy. In classical physics, construction of a measuring apparatus of any finite precision is only a matter of care and expense. The uncertainty principle, on the other hand, is a different kind of statement It implies that any kind of measurement contains a 'built-in' error which can not be improved upon, no matter what the sophistication of the measuring apparatus. The uncertainty relation is thus a theorem concerning the natural limitation of all measurement. To repeat, one can not build a measuring device which will make a simultaneous measurement of position and velocity to any greater accuracy than is implied in the uncertainty principle. From the stand point of microscopic physics, the uncertainty principle is a curious statement, and its meaning is fully realized only by considering the basic act of measurement.

When the position of a particle is measured, in the very process of measurement, one must devise some means to see the particle. For this, one can bounce a light photon off the particle. Obviously, such procedure disturbs the particle so much that its momentum is not what it was before the position measurement. Hence the accuracy of the measurement of position is achieved at the cost of the measurement of the momentum of the particle.

Of course, some examples in classical physics, too, can help to understand the nature of uncertainty principle. We, sometimes, observe that the very act of measuring disturbs the object we are

trying to measure. A voltmeter placed across a circuit may draw a small amount of current and so lower the original potential difference slightly. Similarly a thermometer used for recording temperature of a body alter its temperature during the process of measurement of the temperature.

Of course, the uncertainty principle imposes significant uncertainties only in the microscopic realm. For example, the uncertainty in measurement of position of a mass of 1 kg whose velocity has an uncertainty of 1 m/s is about 10^{-34}m, a distance some 10^{21} times smaller than the radius of the electron. However, for an electronin orbit in a hydrogen atom, the uncertainty is of the order of 10^{-10}m or about the size which is usually ascribed to atoms themselves.

Similarly, if we take 1 second to measure the gravitational potential energy of a block of wood, the uncertainty in measurement can be as small as 10^{-34} joules, hardly enough to worry about. On the other hand, if an unstable particles decays in 10^{-22} second, then the uncertainty in the time during which we measure its energy cannot be larger than that and therefore, the uncertainty in energy is 10^{-12} joules that is about $10^7 ev$, which can make a difference in the nature of the decay process itself.

Thus, we see that modern physics extends its horizons far beyond the everyday experience upon which all the common-sense ideas of classical physics were based and we are thus bound to find striking deviations from our conventional way of thinking and must be prepared to encounter facts that sound quite paradoxical to ordinary common sense. Quantum mechanics is basically statistical in nature and hence the uncertainty inherent in the quantum mechanical description of nature can not be overcome by experimental ingenuity. Many attempts have been made to find logical escape from the restrictions imposed by the uncertainty principles, but no one has ever succeeded. Furthermore, the restrictions agree with the results actually observed in experiments with elementary particles

Probing The Secrets of The Solar System

A. A. Gurshtein

ON OCTOBER 18 at 4 hours 31 minutes universal time the Soviet interplanetary probe Venus 4 completed its 128-day, 350-million-kilometer journey over a heliocentric orbit and released a 383-kilogramme instrument pack for the final descent by parachute to the surface of the mysterious planet. Automatic devices measured the pressure, density, temperature and chemical composition of the Venusian atmosphere and relayed the information back to Earth.

The soft landing thus effected on Venus—a fitting accomplishment in this jubilee year of October Revolution—marks a new stage in the systematic exploration of the solar system undertaken by Soviet scientists. It was preceded by the first soft landing on the Moon by the Soviet Luna 9 and the orbiting of the Moon's first artificial satellite, Luna 10, last year.

The trajectory to Venus, or to any other planet of the solar system for that matter, can be worked out practically for any time—thanks to electronic computers and our knowledge of the laws of celestial mechanics. But because of technical considerations the launchings must be made when the Sun, Earth and Venus stand in a definite relationship to one another.

The most favourable junctures recur roughly every 19 months, the time it takes for Venus, which makes one revolution around the Sun in 224.7 terrestrial days, to return to the same reference position in the sky. The duration of each opening is about 14 days. This sets the timetable for all launching sites in the world—the Soviet as well as the American.

So far six space vehicles have been fired at Venus. The first was on Feburary 12, 1961, when the Soviet Venus 1 was launched. The next opportunity in the summer of 1962—was used by the U.S. scientists to send Mariner 2 on its way. The spring 1964 opening was skipped, but in November 1965 the Soviet space vehicles Venus 2 and Venus 3 were launched. And in mid-June this year the Venus 4 and Mariner 5 were

Reprinted from New Times, Moscow No. 44, 1, November 1967

sent out within two days of each other.

The long intervals between favourable junctures pose added difficulties before scientists and designers. To build and launch a space vehicle requires the concentrated labour of thousands of specialists and substantial material expenditures; every detail and contingency has to be given due thought in advance. But it must also be remembered that missing an opening would put off the project, in the case of Venus, for more than a year and a half, in other words, mean the loss of precious time. Hence maximum use should be made of every opening. From this standpoint the Soviet 'double shot' of 1965 when two probes with different assignments were sent off was of exceptional interest. Venus 2 and Venus 3, the first to carry the Soviet emblem to the planet, provided data which ensured the success of Venus 4.

The flight of Venus 4, a 'flying laboratory' weighing 1,150 kilogrammes, threw new light on the physical properties of outer space. Venus was found to be surrounded by a faintly detectable hydrogen corona, and a lack of magnetic field and radiation belts.

The magnetic field and radiation belts of planets are correlated to their axial spin. Radar studies show that the Venusian spin greatly differs from that of the Earth; the rotation is in the opposite direction and the Venusian day equals 243 of ours. However, observations made by French scientists at the Pic due Midi high altitude observatory reveal a far faster rate of rotation of the planet's cloud cover—with periods of four terrestrial days. The discrepancy between the two made it difficult to say what really was the speed of rotation Now the absence of a magnetic field and radiation belts established by Venus 4 may be taken as indirect confirmation of the radar findings. The optical observations therefore suggest that the atmosphere of the planet is in a state of violent turbulence.

Highly important is the information obtained on the properties of the Venusian atmosphere. The transmitter of the instrument pack began working at a height of 26 kilometres and continued sending back data for 94 minutes until the landing, when some interference with the antenna blacked out the signals. During the descent the temperature ranged from +40 to +280 degrees centigrade and the atmospheric pressure from one to about twenty times that on Earth—a severe test indeed for the instruments.

To ascertain the composition of the atmosphere, five of the eleven gas analysis capsules took tests at an altitude of 26 kilometres, as soon as the parachute opened, and the remainder at some 23 kilometres. The findings may therefore be considered reliable.

The Venusian atmosphere, it was found, consists almost entirely of carbonic acid gas, with an oxygen content of 0.4 per cent and water vapours accounting together with the oxygen for no more than 1.6 per cent. The analyzers, with a threshold sensitivity of 7 per cent did not detect any nitrogen

This came very much as a surprise. Hitherto Venus has been regarded as the Earth's twin planet. For one thing, there were the similarities of size and mass, and other resemblances were conceivable. Now there are far less grounds

[illegible] exception. With its magnetic field and radiation belts, the composition of its atmosphere, its abundance of free water and other physical features, the Earth differs greatly indeed from the other bodies of the solar system.

As far as Venus is concerned, we have now moved on from guesswork to the solid groundwork of facts. Only yesterday the surface of the planet was visualized by some as a scorched, waterless desert and by others as a vast, boundless ocean. Radio astronomers found evidence of extremely high surface temperatures, but this was questioned on the grounds that the findings could well have been affected by an ionosphere or electrical discharges in the atmosphere. As for atmospheric pressure, the range was enormous, though most investigators were inclined to accept a moderate mean in the neighbourhood of five terrestrial atmospheres at the surface. Today Venus 4 has provided the researcher with reliable experimental data to go by.

The aims pursued by the U.S. space researchers in launching Mariner 5, which coursed past Venus at a distance of 4,000 kilometres one day after the Soviet probe made its soft landing, were similar to those of the latter, though the methods used were indirect instead of direct.

At one time it was thought the Mariner programme, under which two successful launchings (one to Venus and the other to Mars) were made out of four, had been completed. It was to be followed by the Voyager project, with the first test launching scheduled for 1969 and the initial interplanetary shot for 1971. But financial difficulties have clouded the prospects and the programme will not get under way before 1973.

U.S. space scientists, however, were against waiting until 1973 and urged that earlier openings be utilized in order to make good, at least to some extent, the lag in the American Venus and Mars programmes. Owing to this pressure it was decided to send up a left over twin of Mariner 4, a 245-kilogramme vehicle with limited capabilities, re-christened Mariner 5.

The renowned Russian astronomer V. K. Tserasky once said that astronomy lives in the past but works for the future, meaning that most astronomical observations acquire added value with the passage of time. The most accurate observations made singly cannot take the place of systematic studies over long periods of time, for only these can trace the evolution of the law-governed regularities of nature. The solid foundation on which modern astronautics rests, for instance, is the cumulative product of painstaking astronomical observations over the centuries.

Astronautics, like astronomy, is projected into the future. The initial flights to the Moon and planets of the solar system of which we are the witnesses hold out the promise that the time will come when they will be mastered by man.

Ever since man cultivated land to grow his food, he has had to wage war against weeds which competed with his crop for light, water and nutrients, thus reducing the food available to him and his family. The methods of cultivation of his land have evolved in such a way as to minimise this weed competition and, even today, many farming practices are directed towards their control. With the rapidly increasing world population, providing more food from the land is as vital today as it was at the beginning of civilization.

The Continuing Struggle Against Weeds

B. J. Heywood

THE importance of the problem is often illustrated by quoting the increased number of mouths to feed. It can also be expressed in lost harvest; for example, it is calculated that in the USA alone the annual cost of loss of crops through weed competition is about 100 million per annum. Effective control of weeds by chemicals is comparatively recent and it really dates from the first use of organic compounds introduced during the second world war. Since that time, many organic compounds have been discovered which give great assistance to the farmer in his war against weeds. Over 120 different herbicides are used throughout the world.

Weed killers, or herbicides, can be classified, as shown in Figure 1, but it must be appreciated that this is a generalised diagram and some can act both as pre-emergence and post-emergence herbicides. Again, it might be possible

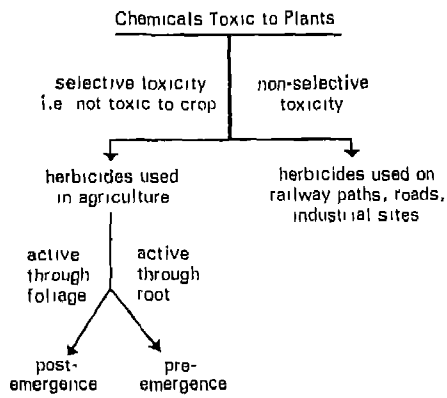


Figure 1

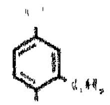
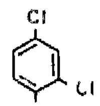
From **Spectrum 41,** October 1967

[illegible] a non-selective herbicide in such a way that it can be applied to a crop without damaging it, perhaps by using a directed spray. Either selective or non-selective herbicides may be needed to control plants in waterways, depending on the circumstances. By far the most important groups are the selective herbicides used in agriculture.

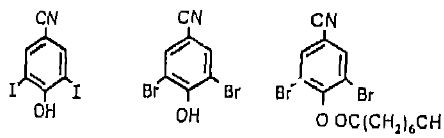
The control of weeds in a crop is a changing problem; as one species is controlled, so another, hitherto insignificant, becomes important as it flourishes in the less competitive environment brought about by the use of the herbicide. We cannot therefore expect a particular herbicide to remain entirely satisfactory over the years. The resistant weeds will start to multiply until a stage is reached when it will pay the farmer to use a new weed killer, perhaps in conjunction with the original one, or perhaps to use different herbicides in rotation. This pattern of development occurred in the weeds present in small grain cereals, particularly wheat, oats and barley, which are the basic source of food for the world population. In the development of new herbicides in cereals, Britain has played a significant part.

From about 1946 the phenoxyacetic acids, MCPA and 2, 4–D, developed by Imperial Chemical Industries, were extensively used to control annual broad-leafed weeds in cereals. (see table below). These chemicals brought an end to the colourful cornfields which were, in fact, infested with yellow charlock and red poppies and the yield of grain was markedly increased. However during the next decade the 2, 4–D resistant weeds, which had originally been of only minor importance, became more numerous because now they did not have to compete to such an extent with the other cereal weeds. Thus, weeds such as chickweed and cleavers not only had the effect of reducing the yield, but caused difficulties at harvest, often blocking the combine harvester. In 1956 Boots Pure Drug Co. of Nottingham discovered that the x-phenoxy-

PHENOXYACID HERBICIDES

Ring structure / Side chain			Year developed
OCH_2COOH	MCPA	2,4-D	1946
	Control of broad leafed weeds in cereals		
$-O-CH(CH_3)COOH$	mecoprop	dichlorprop	1957, 1961
	Particularly control of cleavers and chickweed		
$-O-CH_2CH_2CH_2COOH$	MCPB	2,4-DB	1955
	Control of broad leafed weeds in cereals undersown with clovers		

propionic acids, mecoprop and dichlorprop, gave control of these 2, 4—D resistant weeds so that again the cornfields had a low weed population. Then, during the next decade weeds until then less important became numerous and the farmer was once more looking for means to control these economically. This time an entirely new class of compound, the hydroxybenzonitriles, such as ioxynil and bromoxynil, formulas I and II (Figure 2), were found to be effe-



I II III

Figure 2

ctive, particularly if used in mixtures with the two earlier groups of compounds. The discovery of ioxynil and bromoxynil was reported almost simultaneously from Wye College of London University, May & Baker Ltd., Dagenham, England, and from Amchem in the USA. May & Baker later found that the higher esters, for instance bromoxynil octanoate, formula III, (Figure 2), were particularly useful in the Canadian prairies. Herbicides have played an important role in increasing the average yield of wheat in the UK from 18.6 cwt per acre in 1940 to 31.7 cwt per acre in 1964.

In many countries it has been found advantageous to grow legumes, such as clovers, at the same time as the cereal, so that when the cereal is harvested the clover ley is well established. A requirement for this farming procedure was that the land should be clean so that weeds do not take the upper hand, but the chemicals mentioned above cannot be used as they are toxic to the legumes. This problem was studied by Professor Wain at Wye College and he thought that the minor variations in the enzymatic processes occurring between plant species could be put to use and so improve the herbicide selectivity. He argued from the well established fact that both plants and animals build up and utilise fatty acids, thus providing a pool of energy These fatty acids are built up or degraded in the living system in units of two carbon atoms by means of acetyl groups (Figure 3). Therefore, if the side

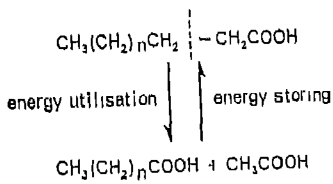


Figure 3

chain of the phenoxyacetic acids was lengthened by two carbon atoms, the plants would remove the last two carbon atoms to liberate the toxice 2, 4-D. Thus, with 2, 4-D sensitive plants, those plants which remove the two carbon atoms efficiently will be killed by the liberated 2, 4-D whereas those plant species which have difficulty in accomplishing this reaction may only liberate 2, 4-D at such a rate that it is inactivated within the plant and so

[illegible] be separated (Figure 4). He found that this was, indeed, the case and the phenoxybutyric acids, MCPB and 2,4-DB were nontoxic to the legumes but toxic to the many weed species. These two chemicals are now widely used in undersown cereals and legume crops.

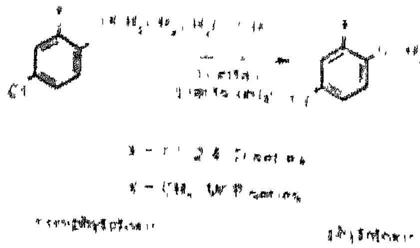


Figure 4

Before turning to other herbicides, it should be pointed out that the cost of the herbicide is a vital factor and economic manufacturing routes must be found if a new herbicide is to get wide use. The preparation of phenoxyacetic and phenoxypropionic acids is shown in Figure 5. The preparation

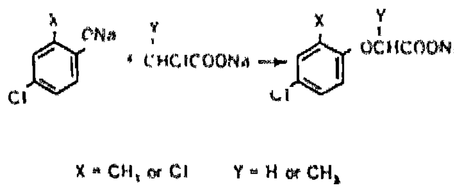


Figure 5

of the phenoxyacetic acid offers greater difficulties since the classical routes would be prohibitive. However, they can be made in very high yield by the reaction of the sodium salt of the phenol with butyrolactone, so the commercial exploitation of these compounds is possible (Figure 6). The prepara-

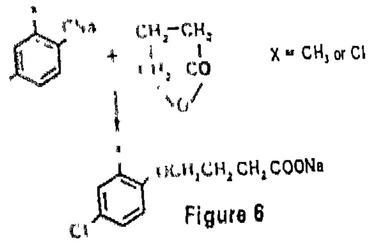


Figure 6

tion of ioxynil and bromoxynil is shown in Figure 7.

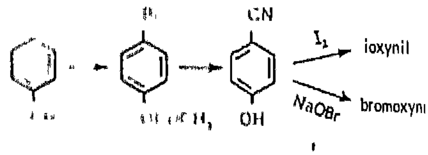


Figure 7

A very important discovery in the herbicide field was made by Imperial Chemical Industries, the full impact of which has yet to be realised. To establish the use of these compounds, the problems faced by the theoretical chemist, the process development chemist, the biologist and the agriculturist would have daunted a less persevering company, or one with smaller resources. The series is known as the bipyridyl group and two members have been assigned the common names diquat and paraquat (Figure 8).

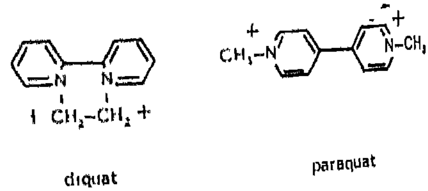


Figure 8

These materials are very soluble in water. When applied to green plants the bipyridyl herbicides cause rapid death. On the other hand, application to the dark or trunk of a tree causes negligible damage. Also, when these compounds fall on soil, they are absorbed with such tenacity that they are completely inactivated. It will be noted that these compounds are pyridine derivatives and so, from the manufacturing point of view, it was first necessary to establish an economic method of synthesising pyridine, the supplies from coal tar being inadequate. It is expected that the paraquat series will prove to have the larger outlet as many of the manufacturing problems have already been surmounted and this series has higher activity against grass species which are becoming a more important weed problem.

The suggested mechanism for the activity in the bipyridyl series is shown in Figure 9, where it will be

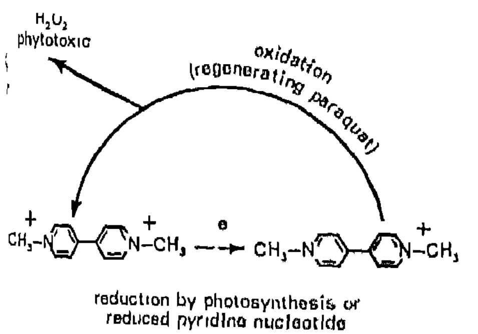


Figure 9

seen that an electron is lost from the molecule by reduction to produce a charged free radical. It is believed that this compound is not harmful to plants, but on oxidation back to paraquat, hydrogen peroxide is formed which is highly toxic to them. The bipyridyls are, therefore, involved in vital process as far as plants are concerned photosynthesis. The more the plant utilises light, the more effective is the catalytic role of the bipyridyl. For this reason selectivity is achieved by limiting the availability of the bipyridyl molecule to the active site. The bipyridyls are used in operations such as destruction of foliage, for instance, to make it easier to harvest potatoes by killing the haulms, or to get rid of leaves to collect seeds. Even more important are mixtures where paraqua is used with a residual herbicide so that on application to, say a potato crop before the shoots emerge, all seedling weeds are destroyed by paraquat and weeds coming up afterwards are controlled by the residual herbicide. Another large potential use of these compounds is in the direct destruction of grassland and re-seeding with cereals or preferred grasses at the same time. It is unnecessary to use the plough, the remnants of the undesirable grass pasture giving protection to the germinating seeds.

The manufacture and use of herbicides in agriculture increases year by year—in some countries the increase in production is 20 per cent per annum. There are many others in use and being developed.

Great attention is paid to the possible effects on man, domestic animals, wild life and the countryside. Big advantages in food production are obtained by the use of herbicides and it is to the industry's credit that, even with exten-

[illegible] use, little change has been noted except in case [illegible] a change [illegible] the [illegible]

It is expected that there will be many new discoveries in the herbicide field during the next decade for, as we have seen, it is unreasonable to expect that any one herbicide will prove satisfactory over a long period. The farmer must have a succession of herbicides but this does not mean that the older ones are no longer of value; indeed, the use of the original herbicides discovered twenty years ago, MCPA and 2,4-D, is steadily increasing. The trend will be to incorporate occasionally either an expensive, sophisticated herbicide or to use combinations of herbicides in rotation to give control of weeds.

Air to the Rescue

JAMES LAWRIE

IF you had the mechanical handling job of moving a heavy load over a floor or surface which was too weak to support it, or if you had to move a heavy, awkward-shaped or a very delicate apparatus over an uneven surface, would you use a Hovercraft? Perhaps not of the sea-going variety, but you could use the same principle. A Hovercraft is a vehicle that moves on a 'cushion' of air generated by the craft itself; it floats on air, so almost completely eliminating friction. The cushion enables the craft to ignore uneven water or land surfaces. The British inventor, Christopher Cockerell, defined Hovercraft as an attempt to extend the uses of a land vehicle to surfaces like the sea.

The fact that Hovercraft are now operating in numerous places with great success caused industry to give the air cushion principle a long, hard look and the air cushion now has some striking industrial uses. Hovercraft Development Ltd., for example, have come up with the idea of industrial lifting pads, a simple example of which consists of a framework to take the load, supported on four circular lifting pads each of which is simply a wooden base fitted with a fabric skirt and a single air feed. The skirt is shaped so that small changes in hover height will give increases in pad area and thus stabilise loads and offset uneven ground.

Pads of 1 to 3 ft. diameter can be operated up to 20 lb/in^2 providing up to 2 in. ground clearance. The individual pads may be placed under convenient positions at the base of the load, the factory airline supplying the pads. The load can be manhandled in any direction. The pads need not be circular and, under a framework, provide a lifting platform. An experimental unit recently demonstrated lifted a 1 ton load three quarters of an inch above the ground, clearing 3/8-in. high obstacles for an air delivery of 50 cfm at 2½ lb/in^2 cushion pressure.

The question of moving really heavy loads is under investigation and it is probable that 1 to 2 ton pallet units and 20 ton containers may be lifted and easily moved by the air cushion method over normal factory floors and ship's decks.

The Elliott Aeroglide conveyor

From SPECTRUM 41, October 1967

[illegible] is a direct application of the Hovercraft principle and consists basically of a [illegible] blower supplying low pressure air to a duct situated below the conveyor surface, a series of valves being connected to outlets in the conveyor surface. These valves, normally closed, open immediately the object to be moved covers their outlets, thereby supplying the supporting air under the object. The valves automatically close once the object has passed.

Objects weighing 1000 lb can be moved horizontally by a force of only 1 lb, or they will travel unaided down an incline of only 5 ft. per mile. Running costs are cheaper than those of conventional conveyor systems. Sacks, bags, brick and concrete products, drums, flat sheets, pallets and trays can all be handled and special "float" tables or floors can be applied to aircraft and other vehicles.

Even the medical profession has turned to air cushioning. In cases of severe burns the pressure of bedclothes and the body pressure from lying down can be painful and retard treatment. To overcome this and so help to speed treatment and recovery of badly burned patients, the National Research Development Council is sponsoring the development of a hoverbed in, or on, which the patient is suspended on a cushion of air, sealed on a narrow band round the body.

Origins of Colour

F. Jones

Colour in substances is normally caused by the excitation of electrons by visible light and the energy of excitation must lie between specific levels if the substance is to possess colour. Dissipation of this energy occurs through thermal and chemical reactions which lead to loss of colour and breakdown of structure. Fading, therefore, is a process inherent in the formation of colour and a coloured compound which will not fade is only a theoretical concept.

ALTHOUGH many attempts to explain the origins of colour on a scientific basis have been made since William Henry Perkin, working at his home at Wembley in 1856, discovered and exploited the first synthetic dye—mauvein—little fundamental progress was made until the 1930–1940 era. The first break-through occurred with the development of the theory of the electronic structure of matter and the second came in the 1940's with the invention of continuous recording photoelectric spectrophotometers which allowed a rapid quantitative assessment of colour to be made.

In order to study the phenomenon of colour it must be realised that when white light, which is composed of all the colours of the spectrum, falls on an object some of the light is absorbed and the remainder is reflected or transmitted. When this absorption process is selective the light entering the eye will be deficient in certain wavelengths and the colour of the object as seen will depend on the wavelength(s) of the light absorbed. Why, then, should some substances absorb light in a particular region of the visible spectrum and other substances absorb light in a different region?

To answer this question we must consider two points of fundamental importance. Firstly, the light absorbed has an associated energy and this energy is directly related to the number of waves per cm of space or inversely related to its wavelength as shown in Table 1. The result of this energy absorption is to cause an electron in the molecule to "jump" to a higher energy level, a process known as a transition. When the molecule as a whole takes up this

From SPECTRUM 51, 1968

energy [illegible] It can only [illegible] its original or ground state [illegible] the excess energy on [illegible] reflectance spectrum of the compond. Figure 1 shows typical absorption spectra for three dye solutions.

TABLE 1

Colour of substances showing single absorption bands in the visible region of the spectrum.

Wavelength ($m \times 10^{9}$ (nm))		Energy K cal $mole^{-1}$	Colour of Light Absorbed	Colour of substance
400	435	71.5-65.7	Violet	Yellow-green
435	480	65.7-59.6	blue	yellow
480	490	59.6-58.4	green-blue	orange
490	500	58.4-57.2	blue green	red
500	560	57.2-51.1	green	purple
560	580	51.1-49.3	yellow-green	violet
580	595	49.3-48.1	yellow	blue
595	605	48.1-47.3	orange	green-blue
605	750	47.3-38.1	red	blue-green

Less than 400 mm ultra-violet
greater than 750 mm infra-red.

to other molecules in the form of heat or chemical reaction, or by re-emitting part of the energy as flourescence or visible radiation. The second point of importance is that the value of the energy difference between the ground and excited states will determine the wavelength of the light absorbed by the compound and in the simplest cases determine its colour.

The absorption of specific light wavelengths can be obtained quantitatively by measuring the intensity of light at each wavelength which passes through or is reflected by a sample of the material, using a spectrophotometer. The curve relating the intensity of transmitted or reflected light to the wavelength is referred to as the absorption

Following this principle that the energy absorbed is inversely related to wavelength it can be seen that the energy absorbed by the red dye will be less than the energy absorbed by the yellow dye since the latter absorbes at shorter wavelengths, i.e. in the blue region of the visible spectrum. These spectra are comparatively simple since only one peak occurs the explanation of the origin of absorption peaks becomes more difficult since we must be certain that any explanation is assigned to the correct peak.

Both inorganic and organic compounds can exhibit colour where electron excitation gives rise to energy differences associated with the energies of visible light.

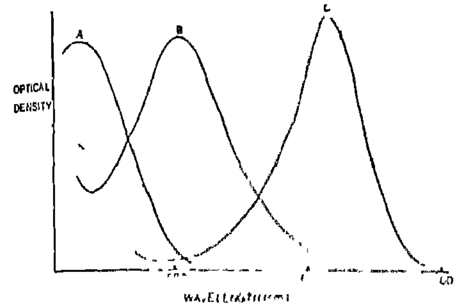


Figure 1: Absorption spectra of a yellow (A) red (B) and green (C) dye solution

INORGANIC COMPOUNDS

Although large numbers of inorganic salts such as sodium chloride are colourless they do possess absorption spectra but these occur in the ultra-violet region of the spectrum since the excitation energy of the cation or anion is very high. The energy required to excite or remove the electron in the negatively charged halide anion, for example, is much less than that required to remove an electron from a cation such as a sodium ion and, although the absorption peak is situated at longer wavelengths, it is still in the ultra-violet region. This type of spectrum is found also with the oxides, halides and sulphides of a large number of heavy metals where the absorption peaks are attributed to the transfer of an electron from the oxide, halide or sulphide anion to the sphere of influence of the neighbouring cation. When these intense peaks extend into the visible region of the spectrum the compound becomes more or less intensely coloured. The red colour of vermilion (Hg S), the yellow, orange or brown ochres of iron oxides, the yellow of cadmium sulphide, Naples yellow (antimony oxide) and the yellow of lead chromate are all attributed to the electron transitions of this type. In Figure 2 the charge transfer spectra of a series of cobalt derivatives containing halogen atoms are shown. The peaks are situated in the u v region, but the bands are progressively displaced towards longer wavelengths as the halogen is changed from fluoride to iodide. This displacement indicates that the transfer process is more easily achieved in the case of the larger halogen atom, since the valency

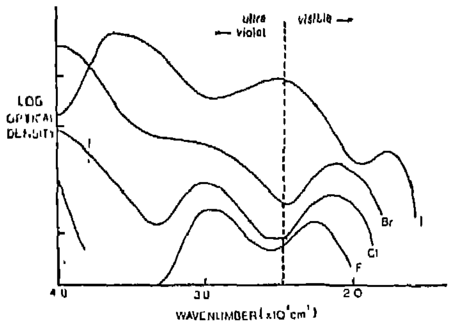


Figure 2: Absorption spectra of cobalt halide derivatives.

electron is more easily transferred when the distance between the electron and the nucleus in the halogen is greater and a larger number of inner screening electrons intervene.

The less intense peaks shown in the visible region in Figure 2 are explained by an absorption mechanism known as a d $\rightarrow$ d transition. This type of transition or excitation process generally occurs at longer wavelengths than charge-transfer transitions since the energy requirements are less. The colour of a large number of metal complexes of the transition metals including titanium, vanadium, chromium, manganese, iron,

cobalt, nickel and copper derivatives, albeit low in intensity, is attributed to this type of transition. In these elements there are five outermost or d-orbitals, each of which can accommodate two electrons. These orbitals are arranged around the nucleus in certain preferred directions in space. If we consider the metal ion as a sphere and its main axes as three mutually perpendicular lines originating at its centre then the preferred direction of three of the d-orbitals lie between these main axes and the other two along the main axes. We cannot consider the metal cation in isolation, however, either in the solid form or in solution the cation is surrounded by negatively charged entities such as halide anions or polarisable groups such as water. These groups interact with the cation by orientation along the axes. Since the groups of ligands as they are known, possess an actual or potential negative charge the interaction between the ligands and the d-electrons lying between the main axes will be different from the interaction between the ligands and the d-electrons lying along the main axes. There are thus two ground states of different energy. This splitting of the ground state energy level occurs when there are one, four, six or nine d-electrons. An ion with two, three, seven or eight electrons has three possible level in the ground state. It is therefore possible for an electron to be transferred from one ground state level to a higher ground state level. Where there are two possible levels one absorption band will be found and where there are three, two absorption bands are possible. Other bands which can occur are attributed to d $\rightarrow$ d transitions from ground states to excited states.

In a simple case we can illustrate d–d transitions in the spectra of copper in copper sulphate solutions and in cuprammonium hydroxide solution. (Figure 3.) $CuSO_4$ crystals and the Cu^{2+} ion in water are pale blue with an absorption maximum lying in the infra-red. The stronger ligand field of the ammino (NH_3) groups in the cuprammonium ion in comparison with water molecules causes the d $\rightarrow$ d transition to occur in the yellow region and the resultant colour (Table 1) is blue violet and more intense. In contrast, the influence of the sulphate ligand in anhydrous copper sulphate is weaker than that of water and the absorption is entirely in the infra-red region and this substance is colourless.

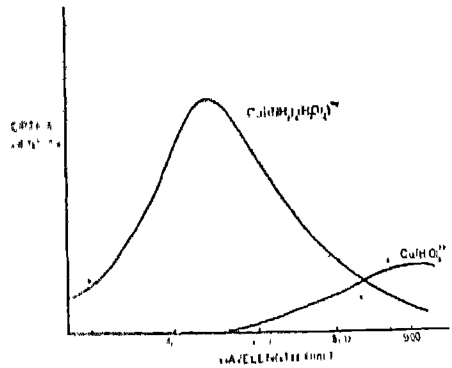


Figure 3: Absorption spectra of the cuprammonium and hydrated cupric ion.

ORGANIC COMPOUNDS

The colour or lack of colour of organic compounds is strongly dependent on the molecular structure since electron excitation in the visible region of the spectrum only occurs with certain atomic configurations. These are com-

pounds containing an extended system of conjugated or chromophores can be seen in Figure 4. Some of the electrons partaking in the double bonds are more easily excited than the electrons associated with the single bonds, since the former are non-localised and their distribution extends over the length of the conjugated system both above and below the plane of the molecule. As can be seen from Figure 4 the effect of extending the length of the conjugated system is to shift the absorption peaks into the visible region. There is however a limitation in that as the conjugated system is lengthened, the wavelength displacement becomes smaller and the absorption peaks do not cover the major part of the visible spectrum. Even with structures such as—carotene, the colouring matter in carrots, where there are as many as eleven alternating double bonds, the colour still remains yellow. Fortunately for the colour chemist there are a number of other conjugated systems which can be utilised as chromophores. One of the most important is the azo chromophore which consists essentially of benzene or naphthalene rings (in themselves conjugated) linked together through azo groups, i.e. a system of double nitrogen-nitrogen bonds. These give rise to intense absorption peaks and when multiple azo groups are present (Figure 5) the colour extends over the whole of the visible spectrum.

The presence of hydroxyl (OH) groups in the compounds shown can modify the intensity and position of the bands since the oxygen of this group and also nitrogen and sulphur atoms in amino ($-NH_2$) or mercapto ($-SH$) groups when present contain easily energised electrons which can take part in excitation transitions

In all these cases we have, then this basic idea of a non-localised electron cloud extending along the conjugated system. The interaction with the electric vector of visible light causes oscillations to be set up within this negatively charged cloud very much like standing waves on a vibrating string. Using the vibrating string analogy, equations representing each harmonic or standing wave are known. Similarly, an equation for each standing wave in the electron cloud can be obtained and from these equations the highest energy level in the ground state and the lowest energy level associated with the excited state can be obtained. From the difference in these two energy levels it is a simple matter to calculate the wavelength of the absorption peak situated nearest to the low energy (red) end of the spectrum. Where this has been done, good agreement has been found between calculated and experimentally determined

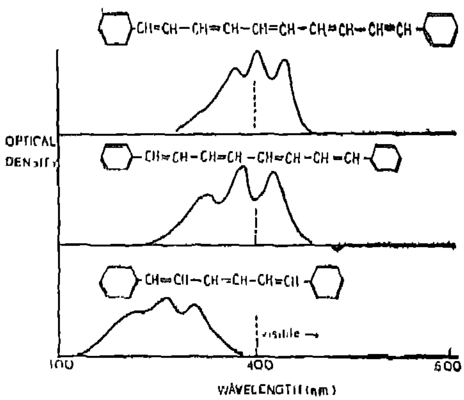


Figure 4: Structure and spectra of diphenylpolyenes.

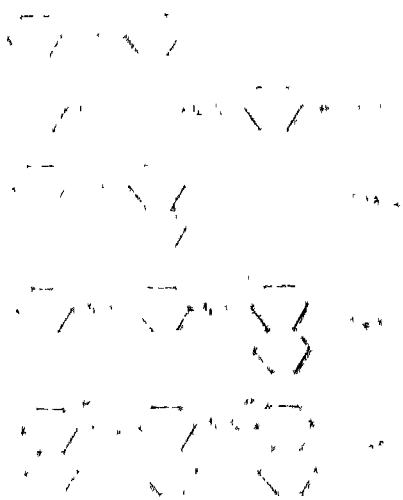


Figure 5: Azo chromophores.

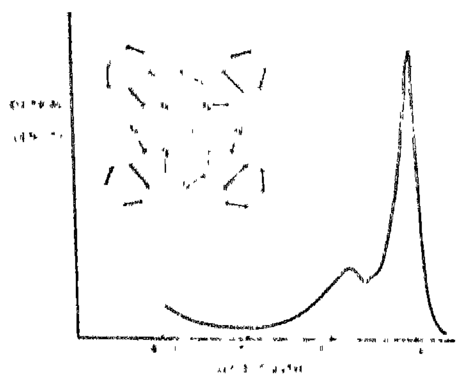


Figure 6: Structure and spectrum of copper phthalocyanine.

values in both linear conjugated systems and cyclic conjugated systems such as copper phthalocyanine, a commercially valuable blue pigment the structure and spectrum of which is shown in Figure 6.

Alongside this standing wave of free electron theory of the origin of colour there are two other main theories. These are the molecular orbital theory and valence bond theory. Former which is based on the combination of atomic orbitals to give molecular orbitals, and the latter which is more concerned with different ionic states existing in organic compounds agree quite closely when simple molecules are considered. For more complex molecules, not even as complex as the ones we have been considering simplifications and assumptions have to be made if agreement between theoretical and practical results is to be found.

The present-day theories of the origins of colour have been developed by the pains taking work of many scientists. Among others in Britain the work of Professor Orgel (Cambridge), Professor Dewar and Dr A. Buraway (Manchester) should not go unmentioned. Notable contributions have also been made by Professors H. Kuhn (Germany) and W. Feitknecht (Switzerland).

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Were the Planets Hot from the Start

Why should the Earth have a hot, molten core? Most astronomers and geologists have generally believed that the reason is somehow connected with events in our planet's history which occurred long after its first formation.

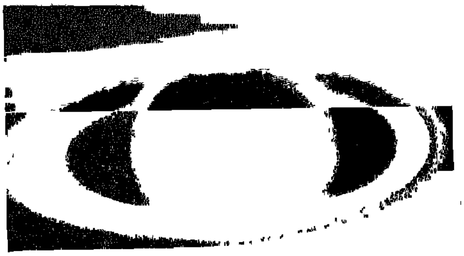
ACCORDING to 'orthodox' theory, the Earth and the other planets were formed in a relatively cold state and have somehow got warmed up since. At one time astronomers thought that the planets were formed when another star came too close to our own Sun and pulled a great streamer of gas out of it, which later solidified and split up into the planets. But today most people believe that no other star had to be involved. Both the Sun and the planets were formed when a huge cloud of gas contracted under the influence of gravity. Up till now, it has been generally agreed that this cloud of gas was cold and so the planets were formed as cold objects when they condensed out of it. The fact that the Earth has a hot, molten core, according to this established concept, is due to events since it was formed.

Prof. Fred Hoyle

Recently [illegible] ... the planets [illegible] ... may be suggested by recent exciting evidence from photographs taken from Lunar Orbiter spacecraft, that the Moon has been in frequent volcanic eruption over periods of many millions of years and may even still have a hot core like that the Earth. Professor Fred Hoyle's new version of the creation of the solar system begins in the usual way, with a cloud of gas much bigger than today's system. The cloud contracted under the influence of its own inward pulling gravitation and this gravitational energy turned into heat. Hoyle's calculation shows that by the time the cloud had shrunk to a hundred million miles across its temperature would have gone up to three or four thousand degrees Centigrade.

To an astronomer somewhere else in space, the cloud would then have looked a very bright star and Hoyle points out that this is a familiar stage in the life history of stars as observed from Earth, their so-called over-luminous phase. At this stage the speed of the inward collapse would increase and as the cloud shrank, so it would have rotated faster and faster-just as an ice-skater spins faster and faster if she draws her arms in. During this spinning, something like five-sixths of the original mass of the cloud was thrown out into space and lost.

Out of what was left, the planets were formed. Not immediately — the rapid spinning first made the contracting cloud of gas spread out again, into a disc about the size of the present solar system. The outer edge of the disc would have been quite cold but the centre would still have been above a thousand degrees centigrade. Out at the edge of the spinning disc, oxygen and nitrogen would liquefy in the cold and carbon dioxide would turn solid, which is why, according to Professor Hoyle, Uranus and Neptune seem to be made of precisely those materials.



One of the major planets—Saturn, showing the characteristic rings

One of the planets of the Solar System

Towards the centre of the disc, magnesium oxide, silica and iron would have condensed and so we find that the inner planets, especially Venus and the Earth, contain most of the iron in the whole solar system. The theory also explains something which used to puzzle astronomers, which is why nearly all the iron in the Earth is in the middle. If the Earth was cold when it was formed, then the iron would have been hard and solid and as Professor Hoyle points out, it is difficult to understand how that iron could have managed to sink through to the centre. But if the iron was collecting at a high temperature, in a semi-molten plastic state, then it is much easier to understand how it flowed into the middle. We still have to explain how the hot Earth managed to collect volatile compounds and gases, such as water, carbon dioxide and nitrogen. According to Hoyle, this happened later. As the cloud of gas finished its contraction into the Sun we know today, the Earth and the other planets around would have cooled down and as Hoyle puts it, would have 'mopped up' any debris.

Classroom Experiments

Experiments for Demonstration of Different Thermal Conductivity in Various Substances

Ved Raina

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In the teaching of school physics it is desired to demonstrate the fact that, 'Thermal conductivities of different substances differ from each other'. For this purpose the following experiments, along with others, are usually described in textbooks and are sometimes demonstrated to students:

Experiment No. 1

The apparatus to show different conductivities of different metals consists of four metal rods of brass, zinc, iron and copper. These metal rods are fitted in a wooden ring, as shown in figure 1. At one end of each rod a piece of phosphorus [illegible] and they are heated at their other [illegible] the help of a burner. Phos[illegible] fire in the copper rod first [illegible] the iron last of all. This [illegible] that out of the four [illegible] the best conductor of [illegible] the least connuctor.

(Manchanda and Gupta, 1965)

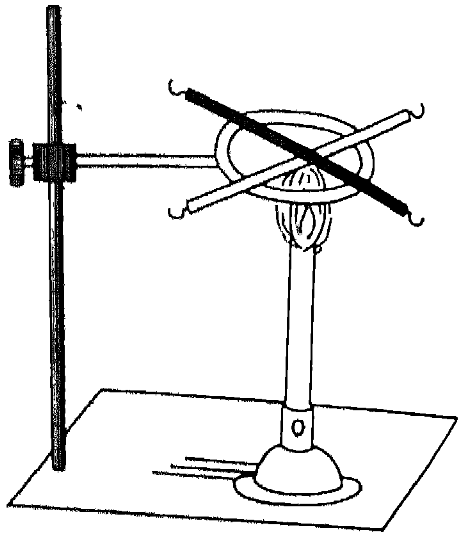

Figure 1

Experiment No. 2

We can compare the conduction of heat in different metals by taking two rods, one made of copper and another made of steel, and repeating the above experiment[1]. The arrangement is shown in figure 2, with iron nails fixed on both the rods. The common terminal is heated by a spirit-lamp. When heating is continued the wax melts and the nails start falling. The iron nails start falling from the copper rod much sooner than from the other rod. This experiment shows

[1]This refers to the experiment of heating one end of a metal rod with nails stuck on it with wax. The nails drop one by one starting from the hot end, demonstrating conduction of heat along the rod.

This is part 2 of this article "A Precaution for Designing Single Experiments in Science," published in School Science, March, 1967.

that copper is a better conductor of heat than steel

(NCERT, Physics 1968)

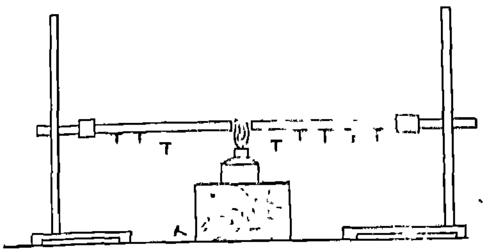

Figure 2

Comments on Experiments 1 & 2

Let us consider these experiments in the light of the following precautions postulated by the author earlier (Ved Ratna, 1967):

In every experiment the observation that we make (or demonstrate to students) is affected not merely by the phenomenon that we want to study or demonstrate, but also by several other factors The conditions of the experiment must be so controlled that the desired phenomenon is the dominant factor. If the conditions of the experiment are not so controlled then the experiment is invalid and a poor demonstration, how-so-ever spectacular it may be.

In the above experiments the velocity at which heat appears to progress along a rod (in fact the velocity at which the ignition temperature of phosphorous or the melting point of wax progresses) depends upon:

i) co-efficient of thermal conductivity K of the material of the rod,

ii) specific heat S of the material of the rod, and

iii) density D of the material of the rod.

Moreover, all these factors are equally important, and it is the expression K/SD which matters. It is called 'thermal diffusivity'.

A comprehensive study of the textbooks mentioned in the references and also of syllabi of various Boards of Education in India reveals that it is the co-efficient of thermal conductivity which we later on emphasize. We do not want the students to worry about thermal diffusivity at school stage. None of these books makes any reference to thermal diffusivity.

Therefore, there is no doubt that when we talk to students about the above two experiments and use words like 'conductivity of a metal' or 'conducting power' or "thermal conductivity", or "power of a substance of conducting heat", etc. we mean the co-efficient of thermal conductivity, K. We want the students later to identify the co-efficient of thermal conductivity with whatever concept students form by these words while studying these experiments.

Experiment 2 described above is usually performed by taking rods of copper and iron. Product of specific heat and density for these two metals is nearly equal (Cu 0 809, Fe:0.826). Thus the velocities at which heat appears to progress (i.e. temperature progresses) along the two rods predominently differ due to difference in their co-efficients of thermal conductivity. But, because while performing this experiment this point is not emphasized, it gives the wrong impression that thermal conductivity is the only factor involved. There also exist several pairs of metals in which thermal conductivi-

ty of one is greater but the thermal diffusivity of the other is greater. This experiment will prove a complete failure with such a pair of metals.

This is why it is highly necessary to design an experiment which can be performed with any pair of metals and which forms the correct concept by not depending or depending to a negligible extent upon the specific heats and densities of the metals involved. The following experiment meets this requirement and is also as much spectacular as experiments 1 & 2.

The Improved Experiment

Experiment No. 3

Take two cylindrical vessels of identical dimensions, shape and wall-thickness. They have glass walls and bases of different metals. Take equal amounts of a volatile liquid, like spirit in them. Put them simultaneously in a trough or beaker which contains hot water or oil. They dip only a little in the hot water. The hot water is stirred intermittently to maintain uniform temperature throughout its volume. Thus the outside temperature of the bases of the two cylindrical vessels is maintained at the same high temperature. The volatile liquid in one of the vessels begins to boil earlier showing that the material of the base of this vessel has greater power of transmitting heat from its outside surface to inside by conduction.

Constructional details of the apparatus

The trough of hot water has a lid and the vessels are fitted in the lid so as (i) to facilitate putting them simultaneously in the trough, (ii) to facilitate dipping their bottoms equally in hot water, and (iii) to eliminate heating of glass walls of the vessels by vapours of hot water. The stirrer passes through a hole in the lid and is given a rotatory movement in a horizontal plane because hot water in the trough is shallow. The metallic bottoms of the two vessels can be removed and shown to students to be identical in shape and size and then fitted water-tight into the vessels with the help of rubber gaskets. It is preferable, though not necessary, that the two cylindrical vessels also have lids on them to eliminate cooling of the volatile liquid by evaporation and thus to perform the experiment quickly.

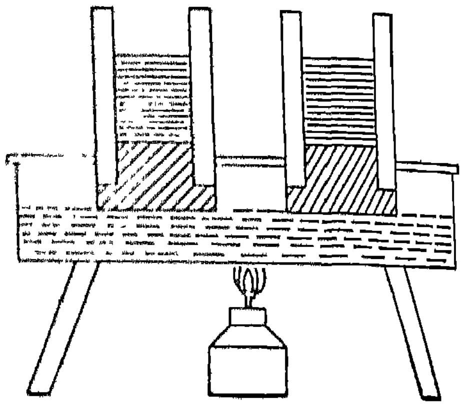

Figure 3

At this point it will be relevant to discuss the following experiment also, which is commonly demonstrated to students.

Experiment No. 4

Good and bad conductors: Take a rod of wood whose one end is fitted into a brass tube of the same external diameter. Wrap a piece of paper round the junction of wood and brass and hold it over a flame as shown in figure 4. It will be seen that while the portion of the paper in contact with the wood is scorched, that in contact with brass is not. This is

due to the fact that brass being a good conductor, conducts away heat more quickly than wood.

(Puri 1962 and Puri and Mathur 1962)

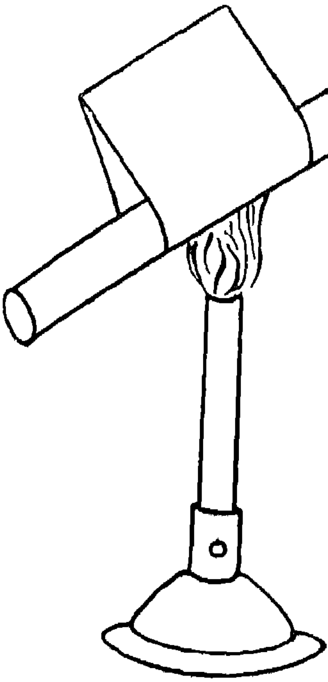

Figure 4

It would appear at the first instance that the comments made above for experiments 1 & 2 also apply to experiment 4. But experiment 4 is used only to demonstrate the broader concepts "Good Conductor" and "Bad Conductor". If this experiment was to be used for demonstrating the difference between two conductors (e g. brass and iron), it will neither succeed when performed before a group of students, nor will it be valid according to the present discussion.

Correct form of Experiment 2

Stewart and Don (1917) have split up the experiment 2 into two parts which gives a very clear exposition of the concepts involved as follows:

Two bars of different metal, but of the same size and shape, and having an exactly similar surface, are placed, end to end, as shown in figure 5. To the under surfaces small wooden balls are attached by wax at equal distances along the length of the bars, which are then heated at their contiguous ends As the heat is transmitted along their length, the wax melts and the balls drop off in succession Now the first ball will drop off directly the temperature of the point at which it is attached becomes equal to the melting point of wax, and, provided the distance of this point from the source of heat be not too great, the time required for this to take place depends not only on the conductivity, but also on the specific heat of material of the bar; because, the lower the specific heat of this material, the greater will be the rise of temperature produced in a given mass of it by the heat supplied in a given time. For this reason the balls may begin to drop off first from the bar which has the lower specific heat, but the greatest number of balls will ultimately drop off from the bar which has the greater conductivity; because, the greater the flow of heat along the bar, the further will the rise of temperature necessary to melt the wax be transmitted

If we take two small cylinders, of equal length, one of iron and the other of bismuth[1], and, after having coated one end of each with wax, place the other end on a hot copper plate, it will be found, that if the cylinders be not too

[1]This part of the experiment, when tried practically, is more effective with iron and lead.

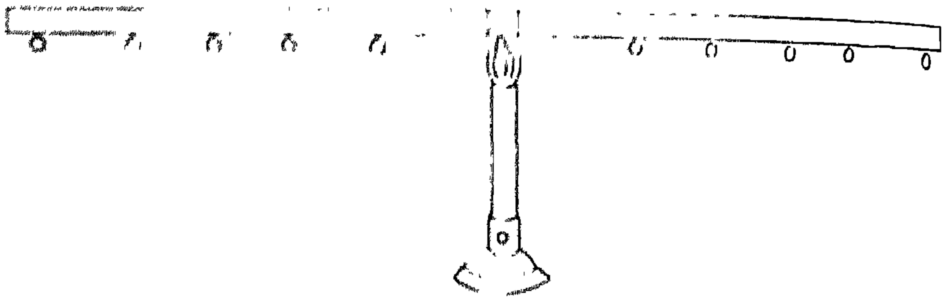

Figure 5

[illegible] the temperature of the plate be [illegible] the wax on the upper [illegible] bismuth melts first, although [illegible] conductivity of [illegible] is [illegible] than that of bismuth.

This is explained by the fact that the thermal capacity of the bismuth[1] is much less than that of the iron, and consequently it requires more heat to raise the temperature of the iron, through a given range of temperature than it does to raise the bismuth through the same range, hence, although the heat transmitted along the bismuth is less than that along the iron, the rise of temperature produced in the former is greater. When, however, the permanent state is attained a greater quantity of heat will be transmitted through the iron than through the bismuth, and the temperature of the upper end of the iron cylinder will ultimately be the greater.

This description by Stewart and Don (1917) is obviously free from the criticism raised by the author, but it is a bit complicated for the comprehension of 12-13 years old students. Similarly, C. L. Datta (1931) has mentioned the following caution, which eliminates the criticism raised by the author:

CAUTION: The quickness with which the wax melts is no sure guide to conductivity, for it depends not only on conductivity but also on the specific heat. Hence, lengths should be measured when the wax ceases to melt.

But unfortunately some authors have not taken any care of being accurate in their description.

Conclusion

It may be concluded that demonstration of thermal conductivity is just one example. There may be many more experiments in our science books and curricula which need deep thinking in this manner. The precaution for designing demonstration experiments stated above is of basic importance in the building up of correct concepts and of scientific attitude among children. Though this precaution seems to be so obvious from the principles of logic that it seems unnecessary to discuss it at such length; it is an unfortunate fact that we sometime tend to forget it when we zealously work upon designing a simple and spectacular experiment. This precaution is all the more important at the present time when we are revising our science curricula in India.

Acknowledgement: The author

[1]By this is meant 'the cylinder of bismuth' here

is extremely grateful to Dr. R. N. Rai for the very valuable and kind guidance that he gave for writing this paper.

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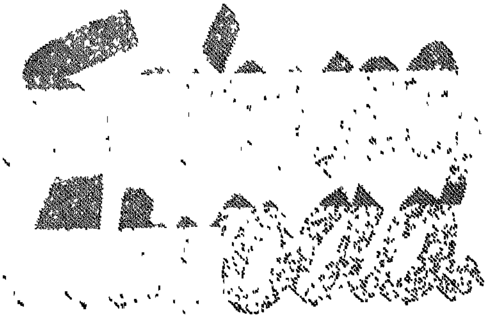

Environmental Science— An Experiment in Science Curriculum in New South Wales

G. R. Meyer

In New South Wales, in 1965, a new type of integrated science course was introduced into the Higher Grades of the Secondary Schools (New South Wales Department of Education 1965). This course tells the story of the total environment of man through the history of the universe from its origin to the present day. It also describes the process of discovery and understanding of the major events in this history. It is thus a quite revolutionary approach to science curriculum and has attracted international attention.

Schools and Science Education in New South Wales

The secondary schools in New South Wales are organised as follows. There is a four year course leading to a school certificate. It follows seven years of Primary School and caters for pupils aged 12 to 15 years, so is approximately equivalent to Indian Middle Schools. Compulsory schooling in New South Wales extends to age 15.

During the four years leading to the School Certificate, there is a compulsory course of integrated science (chemistry, physics, biology and geology) for all pupils, taught at four levels catering for the quartiles of ability and interest. It requires 6 periods per week.

The last two years (5th and 6th forms) lead to the High School Certificate. Increasingly large numbers of pupils continue after age 15 and almost 80% of fourth from pupils continue into fifth. The Higher School Certificate can give University matriculation at age approximately 17 years and so 5th and 6th forms in New South Wales are approximately equivalent to the Higher Secondary Schools in India. For the Higher School Certificate five subjects are taken, but Science is not compulsory. Approximately 70% of pupils, however, take science. Science is arranged in four alternative programmes catering for differences in ability and interst. Three of these are tightly correlated programmes of predominantly physical science with optional strands of either biology or geology. One programme is 11 periods, another 9 and the third 6 periods per week. The fourth programme (six periods per week) is the

course of environmental science. This has been designed as a terminal programme for people who show interest in science but who do not wish to study science at University. These people could include future students of Arts, Law or Economics or those who may not wish to proceed to university but to programmes of teacher education or alternative tertiary training.

The course is an attempt to cater for people who normally turn away from science. It is deliberately aimed at appealing to pupils basically interested in the humanities. By closing this gap it is hoped that science will now be available in some suitable and attractive form for all students in New South Wales. The course has been in operation now for three years and it is popular and successful. Increasingly large numbers of pupils are taking the programme and are responding well to its challenge. The following account of the course is based on an article that has been published elsewhere (Meyer, 1967).

Why Science for All?

Pupils at age 15 going on to Higher Secondary School may be given all sorts of advice. This is the time that decisions must be made about subjects that will be studied for matriculation. A friend may say "Science is dull and hard, you would be very foolish to go on with more Science". A relative may say, "Boys should do Science, girls should take History or Music or Art instead". Another relative may say, "What's the use of taking Science anyway? You're not going to use it when you leave school". Still another person may give advice to "study Science at school and then do Medicine at university and earn lots of money". All this is bad advice.

In the first place, Science isn't dull; it can be deeply interesting, even exciting, secondly, in spite of the pessimism of the friend who said Science is hard, it is certainly no harder than many other subjects. Then the friend who said girls should avoid Science was way off the track. Quite apart from the fact that there are and have been many famous women scientists, today all women need to know about Science if they are to be good housewives and good mothers. This is also part of the answer to the friend who said that science won't be used after leaving school.

Today everyone needs to know about and understand Science, and the more they know and understand, the more meaningful and more worthwhile will be their lives. Knowledge and understanding of Science deepens our knowledge and understanding of ourselves and our environment, and so it enriches our lives. Science is not just for the few, it is for everybody. This is why the advice to study Science at school only for the reason that later on a pupil will be able to become a wealthy doctor is a bad advice. It is encouraging the study of Science for the wrong reasons.

Of course it is necessary to know and understand about science to be a doctor, or indeed to be an engineer, a nuclear physicist, a biologist, an architect, a modern farmer, a veterinarian, a dentist or a pharmacist; but to take science at school only because later you

want to train in a scientific profession. always fails to understand what science has to offer to you as a person.

Science for Everyone

Everyone should study as much science as possible while he is at school. It is not true that the science courses for the School Certificate in Australia or for the Middle Schools in India gives enough knowledge and understanding for the average citizen living in these countries in the 1970's, and the 1980's and the 2020's. In the Higher Secondary School pupils should take all they can what they can. They will need science in their future lives.

Of course, it is true, that some people are better at Science than others. Some especially excel in the logical precision of the mathematical arguments used in say nuclear physics, or genetics. On the other hand for others, this aspect causes difficulties. This difference has been catered for in New South Wales in the fifth and sixth form programme by having the syllabus arranged in the various levels. Students good at Science, liking and doing well in mathematical aspects, usually take the more specialized courses.

For the remainder there is the course of Environmental Science. This syllabus does, of course, include some Mathematics. It would be questionable if it could be called a science programme if it did not, but this mathematics is kept to a minimum and what is required is an ability to think quantitatively rather than work through the steps of intricate mathematical problems.

The fact that some people comparatively less able to understand quantitative science than others does not mean that they are, in general, less able. They may excel in Art or English or History or Foreign Language; in fact they may be much better in these subjects than some of their friends who always beat them in Mathematics or Science. The environmental course is designed just for these people, and it is possible (I'm not sure about this) that these people are in majority. The course caters for people who are probably better in the humanities than they are in the sciences. It is not an inferior course, it is one catering for a different type of ability.

It is this course that is especially designed to enrich understanding of ourselves and our environment. It is a course designed for everybody.

Content of the Course

The information in the syllabus is unusual. It presents a panorama of both the history of the universe, including the biological history of man, and the history of man's scientific exploration of his total environment. The syllabus tells a continuous story from the beginning of time, from the origin of the universe, through the story of the stars and the formation of planet earth, tracing the history of the planet to the time the life began.

It then follows through the history of living things on earth, especially the history of man and, finally, develops the story of man's gradual mastery of his environment to the point where he is today — on the verge of engineering himself and his environment to moulds

of his own choosing. This is powerful stuff. There is detail to be learnt, to be sure, but this detail is there only to establish and reinforce the big concepts that explain the story unfolded by the course. These concepts include "the nature of matter", "the origin of life", "the concept of energy", "the cycles of erosion and deposition", "the process of evolution", "the modern tools of science and technology", "the principles of conservation" and so on. Understanding of these big concepts helps us understand both ourselves and our relationships with others and with our natural and man-made surroundings. Understanding leads to greater control, deeper understanding and greater mastery of ourselves and our environment is a key to successful, happy and enriched living.

Habits of Thinking

The syllabus encourages habits of thinking that should hold good for all situations and throughout life. Understanding involves the ability to comprehend knowledge, that is to recognise knowledge in new situations, different but similar to the situation in which it was first learnt. Understanding also involves the ability to apply knowledge to new situations. It also involves the ability to analyse information — to identify parts, to recognise the way the parts are connected or interact together and to identify the principle or principles that hold the parts together. Understanding also involves the ability to synthesise information; to put parts together in a new way to create something that was not there before.

Finally, understanding involves the ability to evaluate information — to judge the value of materials and methods for specific purposes. The concepts of this course must be understood, not just learnt off by heart, and the relationships between them must also be understood and not be learnt off by heart. The syllabus requires training in the comprehension, application, analysis, synthesis and evaluation of knowledge. These are the skills that are used to gain understanding of any problem — whether it be the causes of radioactivity or the problems involved in choosing the appropriate sort of cake-mix at the local supermarket. Of course these sorts of abilities should be developed in any school programme, but the focus on concepts in the course of environmental science, especially encourages their development.

Emphasis on Solving Problems

The course places emphasis on the methods used to solve problems, methods that hold true equally for a scientific investigation or for solving day-to-day problems in home or office. I would like to quote from the Preamble of the syllabus itself — "There should be emphasis on the methods and techniques of science investigation . . . Students should understand the need to distinguish between observed fact and hypothesis with emphasis on reasons for stating hypotheses . . . The place of authority should be examined so that students must recognise evidence based only upon statements by others. Control experiments, their nature and importance, adequate and inadequate sampling, accuracy and the

[illegible] all must [illegible] discussion. Practical work should provide opportunities to stress the importance of [illegible] in recording results, the danger of accepting fallacious connections between effects and possible causes and the need to avoid assumptions based on inadequate evidence."

These are the sort of things a scientist must understand, but they are also the sort of things all people should understand if they are to control and not be controlled by the complexities of their surroundings.

Development of Appropriate Attitudes

Another quality of the course that gives it an important role in general education is the attitudes and points of view it encourages. I would again like to quote from the syllabus itself -- "In discussing the contribution of Science to the cultural and social development of man the importance of the scientific attitude in fields other than Science should be stressed, the open mind, the suspension of judgment, the readiness to recognise the effects of emotions, habits and prejudices on judgments and observations and the willingness to give up an untenable hypothesis are all elements of this attitude". In placing emphasis on how man has learnt to master his environment, the course encourages development of these unbiased and objective attitudes.

Unusual Methods of Teaching

The course is unusual in the method of teaching advocated. A very high proportion of the lessons are best taught away from the school, out in the community or in natural surroundings of bushland, seashore, mountain or valley. This stresses the extension of education from something that happens only in lesson periods at school to something that happens everywhere involving everyone at all times. Education is a continuous process throughout life. In that this programme blurs the edges between school and non-school it points towards this and helps school students get ready for the education of living.

Textbooks and Evaluation

A textbook has been published for the course written by teachers and a university science educationalist. (Cull, McDonnell and Meyer, 1966) This book stresses the processes of science and has taken the historical story of the syllabus as a theme for showing how scientists work and how great discoveries have been made. To accompany this book a volume of unit tests has been produced (Cull, McDonnell and Meyer, 1967). This encourages pupils to use tests for self-diagonsis of problems and difficulties and to give guidance in study. It encourages teachers to use continuous evaluation as a teaching aid.

Final tests of achievement are set by the N.S.W. Department of Education. These examinations contain only multiple choice questions that stress achievement of understanding of the broad objectives of the course.

Orientation of the Programme

There is a final quality that sets the course aside from other Science courses in the fifth and sixth year programme. This is simply its over-all purpose and orientation. Its avowed objectives are not merely to prepare people for entry into scientific professions but to give them knowledge and understanding of basic concepts and of the application of these concepts to everyday living. It is the fostering of objective enquiry, and the development of mental skills and appropriate attitudes that are essential to a meaningful life in the last decades of the 20th and the first decades of the 21st centuries.

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The Nuffield Foundation Science Teaching Project—VI: Laboratory Facilities For Biology Teaching

W. H. Dowdeswell
and P. J. Kelly

THE work of the Nuffield Biology Project reflects a wide range of ideas for improving biology teaching that have been advocated in this country for several years. It is significant that in many respects the fundamental aims of the Nuffield work are essentially those of new courses developed, or being developed, in other countries. Anyone who has encountered the materials of the Biological Sciences Curriculum Study produced in the United States will realize the truth of this statement, while the reports of the Organization for Economic Co-operation and Development (OECD), the Commonwealth Education Liaison Committee (CELC) and UNESCO all endorse the acceptance of these aims as guidelines for the immediate future. Any consideration of the facilities required for biology teaching must be viewed in the broad light of this consensus of opinion and the momentum of the developments it has stimulated both as regards what is taught and how.

The essential features of the new biology courses are twofold; they cover a wider variety of materials than in the past and they emphasize an investigatory approach. As a result a number of new trends are emerging in the teaching methods employed. Individual or small-group practical work now plays a major part. The distinction between practical work and other activities is no longer so apparent: discussion is closely integrated with practical investigation; demonstrations are used as the foci of problem-solving activities, not just for imparting information; and film loops, photographs, models, tables of experimental data and other sources of evidence are used in close association with laboratory work.

The widespread desire for a revaluation of school biology teaching arose partly from a feeling among teachers that an entrenched, dogmatic approach to the subject was destroying its ability to adapt to changes brought about by new discoveries and new social and educational needs. No one wants one dogma to be supplanted by another and, indeed, the rate at which the science of biology is advancing and

Reprinted from THE SCHOOL SCIENCE REVIEW: Nov., 1967

teaching procedures are being devised or improved, requires that facilities should be as flexible and adaptable as possible. It has been said that buildings and benches are the most conservative influences in science education. In future we must accept that these, together with other facilities, must be of a form that can be modified to meet the demands of a realistic and continuous programme of curriculum development.

In planning for educational facilities we have also to bear in mind the changes that can be expected in the student population. For biology there is a growing opinion that, in future, a much greater proportion of pupils at all levels of secondary education should be given the opportunity to take the subject, and there are indications that more will wish to do so. In addition, the trends towards comprehensive schooling and the broader range of abilities of students staying on into the sixth form will require the use of a greater variety of syllabuses and teaching methods.

The Learning Environment

If biology courses are to be run in a manner that encourages investigation, discussion and thought it is essential not only that adequate materials are provided, but also that the pupils should work in an environment where such activities can be promoted. The atmosphere of this environment will be generated primarily by the teacher, but there are a number of considerations (most of them fairly obvious) affecting the provision and arrangement of facilities that can contribute to an effective learning environment.

1. Facilities should be organized so that they can be easily utilized. Administrative problems cause time to be wasted and can destory a carefully fostered spirit of inquiry more readily than any other factor.
2. There must be provision for a certain amount of 'ordered chaos'. Investigations with living animals and plants have a well-known tendency not to proceed according to plan and invariably result in problems of cleaning-up and waste disposal. Unless adequate provisions are made to meet such exigencies poor laboratory discipline will develop and learning will be impeded.
3. Some facilities should be available to pupils outside normal timetable hours. Inevitably, a number of biological investigations are long-term or cannot be adequately completed in a teaching period. Individual project work for instance, is largely of this kind.
4. The arrangement of laboratory furniture should allow pupils to undertake work in groups of varying size. Some laboratory exercises can be done by individuals or pairs of students. Others can best be done by larger groups. Also, a teacher will wish to use discussion or demonstration at times, either for the class as a whole or with small groups. It is essential that the teaching laboratory meets these demands.

[illegible] LABORATORIES

[illegible] In the [illegible] which follow we suggest certain [illegible] the teaching of the new [illegible] courses.

1 Pupils' working areas

Pupils require a working space that can be used for a variety of tasks. It should be suitable for work with different types of apparatus. Books, tables of data and photographs may be used in association with practical work and there is also the writing-up of experiments to be done. An uncluttered surface is therefore needed with easy access to services. Obviously, the more room there is the better, but a surface area of nine square feet for each pair of pupils appears to be about right.

For O-level work, one gas tap and electric point per pair of pupils is enough. It is far better to have a few well-sited, large sinks than a lot of small ones. One per six pupils should be ample. At least one sink should have a hot water supply.

The surface of the benches needs to be kept as clear as possible. Bottles of chemicals and reagents kept on the benches are a hindrance. So are sinks placed in the middle of a bench top.

Formica or similar plastic bench surfaces which tend to buckle and become slippery are not recommended.

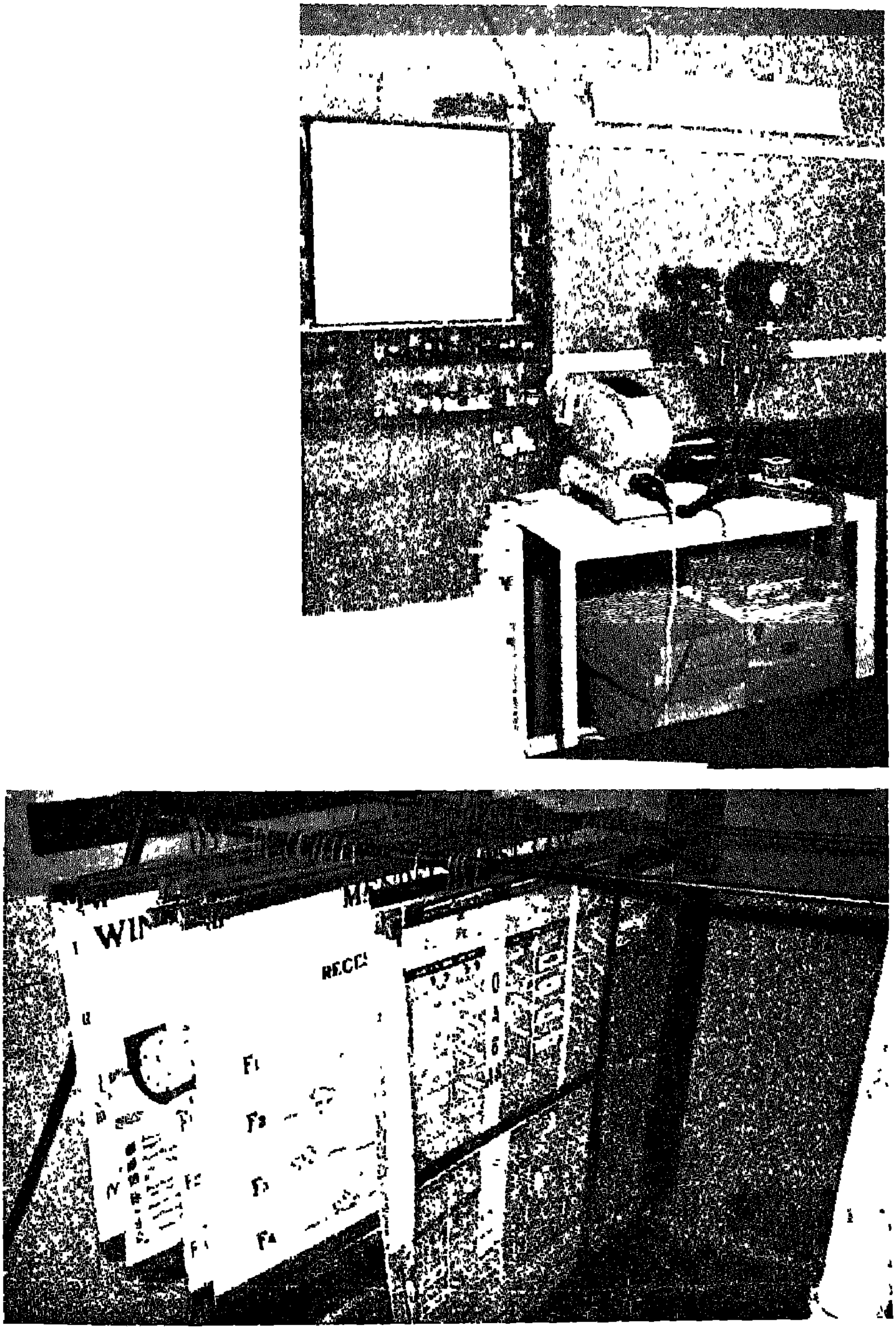
Because of the wide variety of items involved storage underneath benches is not easily arranged. A shelf (not a drawer or cupboard) on which pupils can place personal belongings and a small rack on which bunsen burners and similar basic equipment can be stored is useful, but otherwise it is important to keep the benches free underneath so that seating is comfortable and stools or chairs can be stowed out of the way.

2 *Specialized areas in a laboratory*

Excluding storage space, which will be discussed later, parts of the laboratory should be set aside for specilized activities. It is important that these are distinct from the pupils' working areas.

(a) Demonstration area

The demonstration bench should be of the same height as other benches; it need not be raised. It should be of a good size (minimum 10' $\times$ 3') and provided with a sink and water supply, gas and electricity (15 amp and 5 amp). Near to the bench, or on it, should be a position for film loop and slide projectors. Ideally, back-projection should be used so that there is no need to bother with blackout. Of course, a large, clear blackboard and facilities for pinning up articles or hanging charts are also needed, but there is some doubt about the value of overhead projectors in a biology laboratory, particularly bearing in mind their relatively high cost.



A demonstration area. (Top) *a small area by the side of a blackboard is here used for showing visual aids. An* **800***E film loop projector is also used in this position.* (Bottom) *charts can be placed nearby and made easily accessible.*

[illegible] ... demonstration ... projector and magnifier so that when these are in use other arrangements are not upset.

(b) A wet bench

This should be about 6 ft long, very slightly sloping and overlapping a large sink. It should be covered with lead or a similar impervious material. On it experiments involving water can be set up, aquaria can be prepared and fresh material laid out.

(c) Living organisms area

Ideally a school biology department should have a separate animal house, a glass house and garden. If well managed, these will provide great educational advantages and ensure an economic and continuous supply of living organisms. However, it is often inconvenient to allow classes access to them or continually to have to transport organisms into the laboratory. For this reason some facilities for keeping living organisms must be available in the laboratory itself. For plants an indoor plant enclosure and/or a Wardian chamber is suitable; far preferable to leaving plants exposed in the laboratory.

A wooden tray set on stout legs or part of a bench can provide the base for a suitable indoor plant enclosure. A four-to-five inch high rim of wood is needed and the surface of the tray should be covered with impervious plastic sheeting. A layer of gravel is placed on top of this. Trays or pots containing the plants rest on the gravel. A cover of transparent plastic stretched over a wood or metal frame will provide protection from dust, retain moisture and some heat.

A Wardian chamber can be suitably built on to a window, preferably one with sliding frames or that opens inwards. It should have some form of shading to prevent overheating otherwise the glass or transparent plastic cover should be coated with a film of whitewash during a hot summer.

One or more laboratory plant enclosures could be built on to a trolley each heated and lit artificially. In addition, extra lighting from 80-W fluorescent tubes in either warm white or 3500°K colour, arranged so that their height from the plants can be adjusted, is necessary for speeding up the life cycles of certain plants and experiments on photosynthesis.

Bench space being at a premium in most laboratories, it is suggested that cages of animals such as mice be kept on shelving over benches or on a vacant wall, or on a trolley provided they are away from draught and fluctuations of temperature.

Particular care has to be taken over the housing of the animals so that they can be easily fed, watered and cleaned. An example of how such problems can be overcome concerns mice. In the Nuffield courses they are used on a number of occasions for growth, physiological, genetical and other studies.

One of the mouse cages found eminently suitable for school use was devised by Dr. M. E Wallace for research work at Cambridge. It consists of a polypropylene bowl of internal dimensions: floor 10¾×8¾ in, height 3¼ in. It is covered by a wire lid sloping down towards the centre of the bowl which is fitted with a clip arrangement that secures it firmly. On the lid a metal plate acts both to hold food and as a cover to the nesting area. A half-pint milk bottle supplies water. Six to nine adults for breeding, or, a trio of two doves and a duck, can be kept in the cage. Three shelves containing four cages each will occupy a wall area about four feet wide by two feet high and will project one foot.

A cage need only be cleaned once a fortnight and food replenished about once a week. Mice tend to smell in warm, unventilated conditions and, in such circumstances, require more frequent cleaning. However this is not a serious problem.

(d) *Cleaning and disposal area*

The main problem of waste disposal in a biology laboratory concerns solid material. This can be collected in wire baskets or plastic containers which can be hung over the sides of sinks and emptied into a dustbin.

In addition to this dustbin, a cleaning and disposal area should have a sink with, if possible, a grinding device in its waste outlet, and a draining board of non-rusting metal or plastic (not wood). One or more containers holding disinfectant are needed for disposing of organic material, particularly used cultures of micro-organisms.

Dirty glassware and apparatus will also need to be collected and cleaned. Again, this is best collected in baskets or containers rather than deposited haphazardly into the sink. A drying rack is also needed especially for glassware. Needless to say soap, detergent, cleaning brushes, clothes and towels should be available and if there is no permanent hot water supply, an Ascot gas heater or a similar appliance will suffice.

There should be enough space around the cleaning and disposal area to allow access for trolleys transporting materials to and from it and to allow people to move freely around.

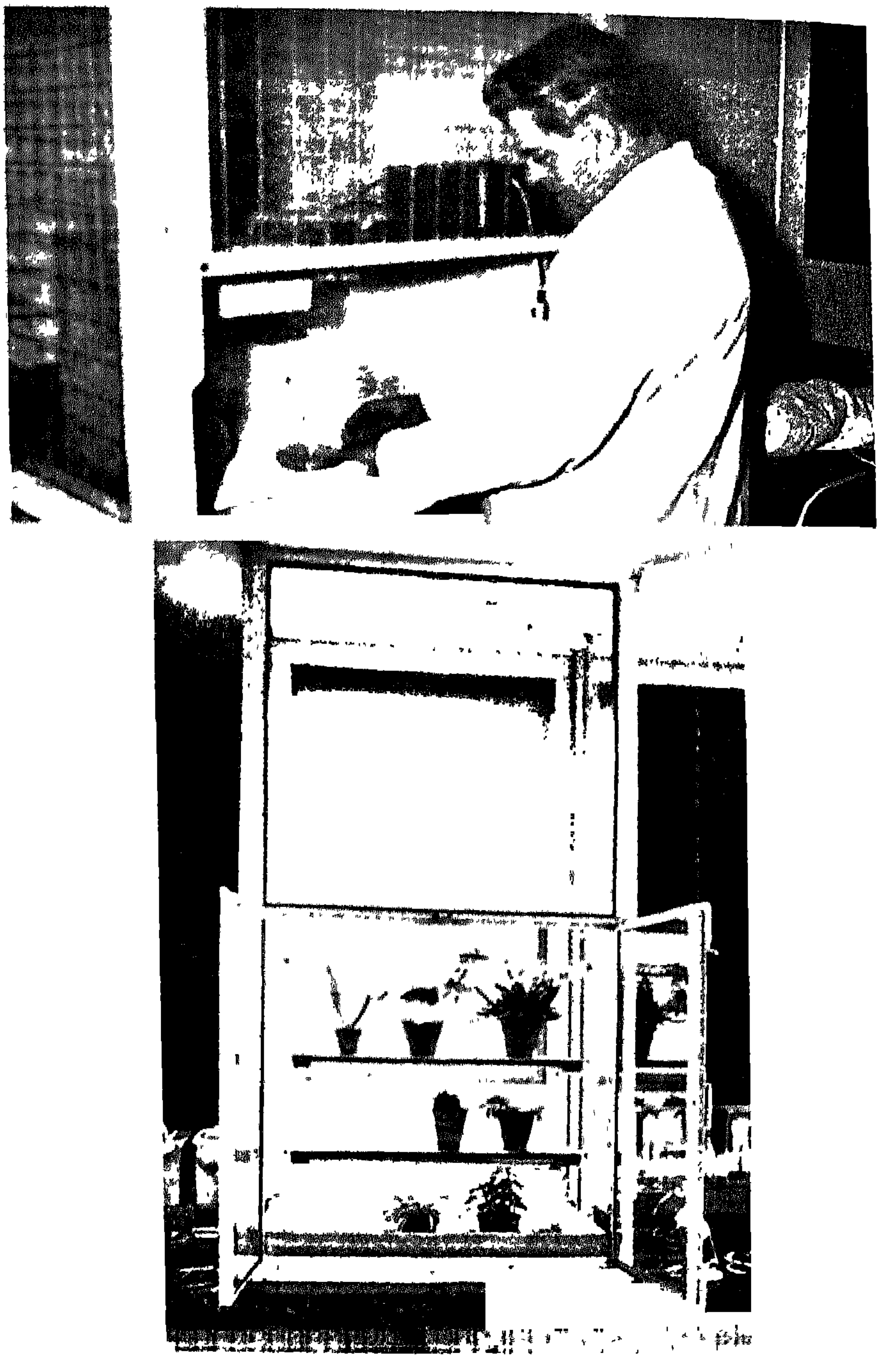
Probably the best situation for this area is in the laboratory itself so that it can be used easily by pupils, but it should also be near the preparation room and sufficiently away from the main teaching area to be used when classes are in progress.

Outside work in ecology inevitably leads to a cleaning-up problem. Somewhere there should be an area where such items as wet gumboots, clothing and nets can be deposited. Good drying facilities should also be available.

It cannot be emphasized too strongly that an adequately organized system for the disposal of waste and cleaning up is essential for the smooth running of a biology course in which experimental practical work plays a large part.

(e) *Long-term investigations area*

In terms of school laboratory management, a long-term investigation is



Specialized areas in a laboratory. (Top) *a small chamber in the corner of a laboratory used for microbiological work.* (Bottom) *a Wardian Chamber built into a window and fitted with artificial lighting*

one that lasts longer than one class teaching period, i.e., it has to be accommodated until the class meets again. While few investigations, other than project work, are likely to take more than a week or a fortnight, quite a number last for a more limited period

In addition, apparatus may have to be left up for some time so that a number of classes can use it. A group of aquaria arranged for investigations of food relationships is a good example, so is the model stream suggested for use in the third year of Nuffield O-level biology course. It can be made from asbestos, cast-iron, galvanized metal or PVC guttering. Water is circulated through it by a suitable pump. The equipment can be used not only for ecological studies such as the influence of substratum of current strength on the distribution of adquatic organisms, but also for rearing trout ova and larvae, work on the matabolism of streamdwelling animals and many other investigations. An allotment of bench space or shelving is clearly necessary for such long-term investigations but this need not be great.

(f) *Clock*

A number of experiments require timing. If the laboratory clock has a second hand it can be used for such work and less reliance need be placed on a supply of stop-clocks or pupils' watches.

Specialized Areas Associated With The Laboratory

Some of the more specialized activities require facilities that need not be in the laboratory itself, but access to them from the laboratory should be as easy as possible.

(a) *Pupils' reference area*

Departmental library. A small departmental library is essential It is not sufficient just to have a biology section in the school library. Copies of the standard reference books, keys and offprint should be available in sets (not just one copy).

Other reference material. The pupils' reference area might also house a collection of film loops, slide transparencies, drawings, photographs, and possibly microscope slides together with the necessary projection equipment. The projectors should be easily moved from this area into the demonstration area in the main laboratory.

A demonstration cupboard or cupboards, a pin-up board for paper cuttings, pictures etc. and a peg-board for hanging up charts and displaying small pieces of apparatus are also extremely useful.

The extent to which it is considered that pupils should have access to materials will, of course, vary with the circumstances of schools

(b) *Projects area*

It is now widely accepted that worthwhile project work by individuals and small groups can be undertaken even within the limited time and resources available to school pupils. The Nuffield A-level Biology Project, for instance, is including project work as an integral part of the scheme now being tried out in certain schools. The main requirement for such work is

space in which experiments can be left undisturbed and this must be considered as an addition to any allocated for long-term class investigations. Ideally a separate, fully-fitted small laboratory is needed, but much can be achieved using part of a class laboratory, a renovated store room or shed, or by utilizing areas in a preparation room or glasshour. We suggest that provision for project work should be given high priority and space that might otherwise be used for storage or display could sometimes more profitably be used as a project area.

The projects room, like the pupils' reference area, should be open both in class time and for some time after.

Even if it is not possible to allow the rest of the biology department to be used by individual pupils, the reference and projects area should be available to them; if necessary on a supervised basis.

(c) *Special subject areas*

Certain types of practical work requiring special techniques or involving hazards, need to be undertaken in areas away from the main laboratory area. Some aspects of microbiological work and experiments involving radioactive materials come into this category.

For microbiological work a small area is needed where subculturing, pouring media and inoculation can be undertaken without undue risk of contamination. The space required need not be large, one or more transfer chambers or a suitably adapted fume cupboard will suffice.

On the whole it is better to confine work with radioactive materials to a special area. Their use is governed by regulations laid down by the Department of Education and Science. However, the experience gained from working with isotopes can be of great value even if it is only on a relatively small scale.

(d) *Preparation area*

This should be as spacious as possible since it is the hub of the laboratory organization. It should not be a storage area nor a through passage for pupils. Here the teacher and laboratory assistant should be able to work unimpeded. Although not an ideal arrangement, part of it could be used as the teachers' office.

Good lighting, gas and electricity points, hot and cold water, a sink and a waste disposal unit are necessary. Adequate bench and shelving space also workshop facilities are needed. Trolleys should be able to move easily within the area.

(e) *Storage areas*

Relatively few large pieces of equipment are used in school biology courses (3).

For storing certain unstable substances such as sera, ATP and nutrient media, a refrigerator is essential. Moreover, it enables recipes to be made up at any convenient time and kept until needed. Mirco-organisms and tissues from recently killed organisms can be kept in a refrigerator for some time and still remain in a suitable state for practical work. A deep-freeze is not a necessity but if one is available, organisms such as mice and fish can be restored to good condition for exami-

nation and dissection.

Bacteria and fungi used in experimental work usually require incubation. Work on development using fowl's eggs and genetical studies with Drosophila also need a regulated temperature above that of the laboratory. Hence one or more incubators are essential items of equipment. These need not be very large or expensive, and some success can be achieved, as a temporary measure, with improvisations such as an acquarium tank heated with an electric light bulb and lined with cotton wool for insulation.

Equipment such as refrigerators, incubators, balances and autoclaves can be kept in specified positions and present few storage problems. Microscopes, on the other hand, are another matter. They are used frequently, and therefore need to be easily accessible, but intermittently and so do not warrant being kept in the pupils' working areas. Some schools have found it best to keep them on shelves, others use a trolley kept in the preparation room. The latter arrangement is an advantage when one set of microscopes has to serve more than one laboratory.

Microscopes need to be kept dust-proof and this is probably best achieved with the use of cloth or plastic covers. On grounds of accessibility, storing microscopes in cupboards is not recommended unless there is a danger of theft or damage.

Dangerous chemicals and other similar materials need to be kept in a cupboard that can be locked.

In a biology course with emphasis on investigation a lot of small pieces of apparatus will be needed. Apart from a few items it is not feasible to store apparatus in the pupils' working areas. It is far better to leave space under the benches for the pupils' legs and their stools or chairs. This helps to keep the aisles between benches free of clutter, increases comfort and so helps discipline.

Efficient storage depends on four factors:

i) the relationship between where the items are stored and where they are used,
ii) accessibility and protection,
iii) ease of transportation of items to and from where they are used,
iv) a system for discarding old and unused items.

In the long run it is worth spending some time and money working out a detailed storage plan for a laboratory bearing these factors in mind. This is particularly true when taking on a new course.

Storage is a problem that cannot be solved on an ad hoc basis. If materials are stored as they are received without reference to an overall plan, inefficiency will inevitably result.

It is well to remember also that storage is essentially a human problem. Pressure of work and familiarity with the surroundings sometimes make it difficult to perceive the real nature of the problem in one's own laboratory. A colleague brought in from the outside can often be of great help with fresh ideas.

(f) *Types of storage*

In many school laboratories today cupboards with swinging doors and fixed shelves are the basic storage units.

Not only do they fail to provide a flexible method of storage, but they often contain a great deal of unused space and it is difficult to load and unload material from them.

If doors are necessary to protect equipment they should slide wherever possible. An excellent type of lock is now available for closing them.[1] Sometimes curtains (to keep out dust) are sufficient, sometimes it is better to have no cover at all. Shelves should be removable and it should be possible to adjust their height.

Portable plastic shelves moulded to hold various bits of apparatus—either of the same type or a collection needed for a particular piece of work—have much to commend them, particularly as they are easy to clean. Otherwise, wooden shelves with a small rim to prevent things falling off can be used. The shelves must, of course, be of a size that allows them to be easily moved.

The provision of more movable shelves and drawers, sometimes in place of cupboards, is one of the main requirements for laboratories which are to compete with work of an investigatory nature.

One way in which storage can be combined with accessibility is by the use of trolleys. These can be literally shelves on wheels, and with a top that provides a reasonable working surface and a simple device like a pram brake for fixing the wheels in position, they can be used in place of fixed benches to provide not only storage space, but a working position as well. They can be wheeled to wherever their contents are needed.

Whatever form of storage is used and wherever it is situated, there must also be space, unhampered by swinging doors and the like, in which to monoevre. Items used regularly should, if possible, be stored at waist height. What is not always appreciated is that storage above this height can be very valuable. In many laboratories, the greatest waste of space is upwards.

There is a powerful argument for having relatively low ceilings in laboratories to help in providing an intimate teaching atmosphere, but if height is in excess, as it usually is, it should be used. Shelves in the laboratory or even a gallery in a preparation room can provide extra storage space for items which are not constantly in use A fixed or adjustable step ladder will be needed.

(g) *Glasshouse*

This should adjoin the laboratory or at least be near at hand. Since the school heating system is liable to be turned off during the holidays, the glasshouse should be heated independently Oil heaters are unsuitable because of fumes and the only satisfactory system consists of tubular electric heaters with thermostatic control.

In the summer over-heating can be a major problem. It can be overcome to some extent by an abundance of open windows, by using venetian blinds or a fan, or by white-washing the glass (or applying a special preparation such as 'Summer Cloud').

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[1]This lock is known as the 'Century No 230' and is made by Humphrey and J. Fox, Ltd., Century Works, Withenhall, Staffordshire.

A small, well-used glasshouse is preferable to a large one unless there is adequate manpower to run it.

If a bench, a sink and electric points are included experimental work can be undertaken and the glasshouse used as an extension of the project area.

The glasshouse is the most underused part of many school biology departments. When integrated closely with class activities it can be invaluable. One is essential for courses such as those devised by the Nuffield projects.

(h) *Animal area*

While some animals can be kept in the laboratory, it is a waste of space to house breeding stocks there. Separate arrangements are required for these. A shed or part of a store room can be sufficient. Some schools have used part of a glasshouse as an animal room, but such an arrangement faces great danger due to over-heating.

The animal area should be well-ventilated but draught-proof and it must be easy to clean. It needs to be kept at laboratory temperature and any animals requiring more heat, e.g. locusts, should have a heating device in their cages. It is an advantage to have a temperature gradient in the area so that one end is cooler than the other (a single window will usually achieve this).

There should be a reasonable source of light and easy access to a water supply. A small cupboard is required in which food and other materials can be kept also a liberal supply of plastic bins for keeping such things as mouse food and for collecting refuse.

Under these conditions it would be possible to maintain stocks of all organisms required for the Nuffield courses

(i) *Outdoor areas*

Ecology receives much more attention in the new courses. This does not mean that access to large field areas is essential, although of course they can be of great benefit. There should, however, be some waste ground, a pool (natural or artificial) or similar small, outdoor habitat available.

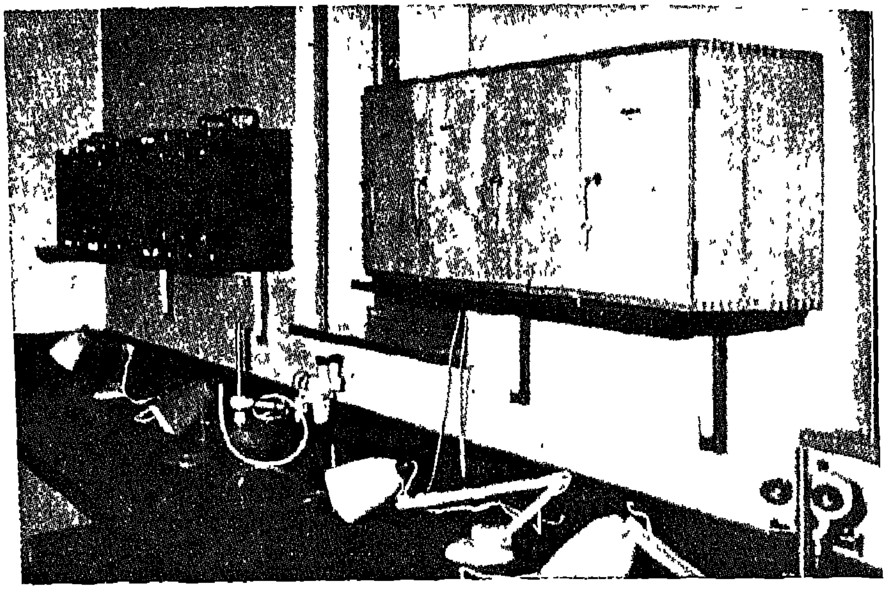
(j) *Rain-water tank*

A pipe leading from a tank just below roof level with a single tap in the laboratory can provide an invaluable way of getting rain water quickly. It is often needed, particularly if the main water supply contains much chlorine or is very hard.

Flexibility

Routine demonstrations by the teacher play a relatively small part in the new courses. Instructions for practical work are provided for the pupils, and the brighter ones can certainly carry on with little assistance. Hence the teacher is apt to spend less time at the front of the class and much more among the students dealing with individual problems. The design of a laboratory for this type of work thus needs to be more focussed on the activities of the pupils than on those of the teacher.

The design of a flexible laboratory is no easy task and we feel there is a need for much more research and development on this problem(4). The teacher has a vital role to play and



The use of wall shelves. (Top) *these microscopes are accessible, but are so situated that they do not interfere with work on the bench.* (Bottom) *mouse cages such as these occupy a relatively small part of a room if kept on wall shelves.*

we would like to see more article on this subject from practising teachers in journals such as The School Science Review. Here are a few issues which seem to use to merit further exploration:

(a) The positioning of services (gas, electricity, water) often governs flexibility in the use of a laboratory Should service centres be attached to benches? Would overhead centres, some placed above benches on walls and some at other positions in the laboratory where movable benches can be attached, be more suitable?

(b) What are the best ways of using movable benches or trolley-benches?

(c) Are pupils' positions best arranged singly or in bays around a laboratory rather than in parallel rows in the centre? Alternatively, would clusters of movable benches around service centres in the middle of a laboratory offer more flexible facilities?

(d) Should we not explore the carrel system (learning system) developed in the United States(4)?

(e) Would the most suitable basic design for a biology teaching laboratory be central space with small bays leading off it(4)?

(f) How should laboratory furniture be developed which is simple in design and multi-purpose in function?

(g) What would be the advantages of having partitioning walls which are movable and bear no load?

No doubt there are many other ideas on laboratory design which could lead to greater efficiency and flexibility.

Conclusion

In this article we have attempted to look at the future physical needs of biology teaching in a general way. We have deliberately avoided trying to produce an 'ideal' arrangement because for most schools reality, in the short term, means adapting to conditions that already exist. Furthermore, developments are still very much at an embryonic stage. While much work has been done at O level, there are developments in relation to CSE (especially relevant to comprehensive schools) and for sixth forms to be considered in the future. Furthermore, a school biology department needs to be organized not only in relation to its own commitments, but also in association with the departments of other related subjects.

However, it is not too early to start thinking about this matter. The provision of laboratory facilities must be seen as a carefully planned, long-term operation. Far too many biology departmets are suffering at present from a succession of short-term, ad hoc improvisations.

The experience of the trials of the Nuffield O–level materials indicated that many biology departments can be easily adapted to the new requirements. In the short term, lack of facilities need not deter schools from, at least, experimenting with the new courses. Often a compromise can be reached by which modifications to the balance but not the principles of a course, allow it to be taught in apparently inimical circumstances. In the long term we must accept that adequate facilities are essential if a high standard of teaching and learning is to be achieved.

Finally, we would emphasize that the provision of adequate laboratory facilities is not an issue that can be treated in isolation, the most lavish equipping of biology departments could never, of itself, meet out present teaching requirements. Three other considerations are complementary and paramount. First, there is an urgent need for more time to be made available to biology teachers for the preparation of laboratory work. Second the widespread shortage of properly trained and properly used laboratory staff must be overcome. Third, there is a need for more efficient organization in the development and supply of equipment, particularly of living organisms. We realize that some steps are being taken to overcome these problems. However, we are not convinced, at present, that they are by any means sufficient.

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Supplement on the Nuffield Foundation Teaching Project's 16-18 Programmes

EARLY in 1964 the Trustees of the Nuffield Foundation recognized that the development of O-level courses would necessitate the development of materials for A-level students. Plans have now been drawn up for programmes of development leading to a number of A-level courses-biology, physics, chemistry, and physical science. The last-named course is intended to present the essential unity of the physical sciences by material drawn from both chemistry and physics.

The planning of all A-level courses is necessarily conditioned by an awareness of the rapidly growing diversity of interest and ability among sixth-form pupils. The sixth-form is growing very rapidly in size and it is essential that courses designed for the sixth-form should be flexible. They must provide the most able pupils with opportunities for serious study in depth, but must also provide a meaningful education for those not continuing their education in science beyond this stage.

Four teams have been appointed to carry out the development at A-level. The A-level biology team is being organized jointly by Mr. W. H. Dowdeswell of Winchester College and Mr. P. J. Kelly, formerly of Bexley Grammar School. The work of this section is guided by a Consultative Committee under the chairmanship of Professor John H. Burnett, Professor of Botany in the University of Newcastle-upon-Tyne and Professor D. R. Newth, Professor of Zoology in the University of Glassgow is vice-chairman. Programmes in the physical sciences are being guided by the Joint Committee on the physical sciences with Professor Sir Nevill Mott, Cavendish Professor of Physics in the University of Cambridge as Chairman and professor R. S. Nyholm, Professor of Chemistry in University College, London, as vice-chairman. The physical science course is the responsibility of Dr. J. E. Spice of Winchester College. The development in A-level chemisty is the responsibility of Mr. E H. Coulson, formerly of Braintree County High School. The physics project is being reconstituted but much of its preparatory work has

Reprinted from EDUCATION IN SCIENCE, April, 1967

been under the leadership of Mr. V. J. Long.

A-level courses were introduced into samples of trial schools in September 1966 in chemistry, physical science, and biology, and final editions of the materials should be published early in 1970 The principles which have guided and determined the O-level developments will continue to influence the courses at A-level. In particular, students will be helped to a scientific understanding by means of experiment carried out individually, but there is clearly, at this level, a need to introduce materials in a less heuristic approach.

The Examinations Boards have been most willing to assist the A-level developments by providing special examinations for pupils from trial schools. Arrangements similar to those for the O-level course have been agreed with all eight GCE examining boards. In particular, A-level examinations will be provided in 1968, 1969, and 1970 in biology, physics, chemistry and physical science. The boards responsible for providing examination papers for candidates from all trial schools are the Joint Matriculation Board in biology, the Oxford and Cambridge School Examination Board in physics, the University of London Board in chemistry and the Cambridge Local Examinations syndicate in physical science.

It was most necessary before trials of the courses could be mounted to be able to assure pupils in trial schools that they would not be handicapped by their involvement in the Nuffield scheme when seeking entrance to universities and we are most gratified by the interest and enthusiasm that has been shown in these experiments. It is clear from the progress to date that physics will be running late compared with the other projects and is consequently not included in this report. We shall, however, be arranging with the A S.E. for its later publication.

K W. Keohane, Co-ordinator

THE NUFFIELD FOUNDATION A-LEVEL BIOLOGY SCHEME

Introduction

The work of the A-level Biology Section started in January 1965 and began with investigations of the requirements of biology teaching in the sixth-form. The organizers worked in close co-operation with the research team of the Committee of Biological Education whose survey has recently been published.

In addition, a series of discussions were held with groups from the Association for Science Education, Colleges of Advanced Technology, Colleges of Education, and University departments of Biological Sciences, Medical and Dental Schools. Close consultation with the many people interested in sixth-form biology has continued in order to ensure that the work of the project will be as relevant and realistic as possible.

A special study was also made of areas of subject matter that appeared to present particular difficulties in sixth-form work.

They were:

1. Applied Biology
2. Behaviour
3. Development and cell biology
4. Ecology, natural selection and evolution
5. Genetics, including population genetics
6. A biological approach to structure and function

In addition a special study has been made of project work and its assessment. Working parties, consisting of teachers and research biologists, were set up to help with this work.

Principal Aims

The work of the Project is aimed at developing certain abilities in the students.

a. To acquire information and a knowledge of the terminology and and conventions relating to the study of living systems.

b. To classify biological data and to synthesize them into generalization and principles.

c. To make relevant observations and ask relevant questions about them.

d. To handle quantitative information and to assess the error and degree of significance involved.

e. To assess critically hypothetical statements with regard to their origin and application.

f. To evaluate the implications of biological knowledge for human society.

g. To analyse acquired biological knowledge and utilize it for identifying and solving problems with unfamiliar materials.

h. To make a creative contribution to solving biological problems.

Underlying each of the above abilities is the need to be able to record and communicate adequately and relevantly both verbally and in writing

We hope the scheme will provide the means whereby students can develop the abilities enumerated above. It will be concerned with biology as a single entity and not divided into separate subjects, botany and zoology.

There will be continual reference to the implications of biology for human society. Pure and applied biology, together with biological technology, will be interwoven in the scheme with no distinction of status. Students should realize that pure and applied biology cannot be dissociated even though the approach to biological technology and pure academic research in biology can be different.

The scheme will be concerned with all levels of biological organisation, namely molecular, cellular, organ and tissue, organism and population. It will provide an introduction to the major syntheses of biology, for example biological diversity; genetic continuity and variation, evolution, and inter-relationships of structure and function, the inter-relationships of organisms and environment matter and energy cycles; homeostasis, development; psychology; information theory in relation to living organisms; and the relationships of different kinds of life cycle.

In the trial version there are four basic courses focused on the organism and built around the themes:

The living community

The maintenance of the individual

organism
The organism in relation to its environment (biotic and physical)
developing organism.

The main feature of the subject matter is that it focuses pupils' attention on living organisms, not just biological principles. An attempt has been made to link the various biological disciplines so that, for example, population genetics and ecology are considered together, applied and pure biology are closely related and, wherever appropriate, physical science and mathematics are introduced in a biological context.

It is important that some degree of choice of subject matter should be available based on particular interests of teachers and students (on occasions these may have a vocational slant). Within the courses some provision for alternative approaches to topics will be made.

Pupils will also be given every opportunity and encouragement to follow specific interests by individual study. For this reason, and because of the unique experience that scientific investigation can give, individual project work is regarded as an integral part of the scheme.

As wide a variety of organisms as possible will be utilized. In attempting to achieve this, we intend to avoid the traditional study of 'types'. Instead, the kinds of organisms used in the different courses will be carefully selected so that while there is a reasonable variety, unrealistic demands are not imposed on the schools and supply organizations.

Wherever possible, organisms will be selected that have some significance in applied biology.

Biology should be seen as a part of human endeavour and as a subject which has been developing over many centuries There are many unanswered questions about life; our ideas of life may change as new knowledge is obtained. Whenever possible, the courses will be linked to life outside the laboratory and opportunities provided for the handling and care of biological material and the aesthetic enjoyment that the subject can provide.

In general we would not include theoretical ideas for which sufficient direct or indirect evidence cannot be produced. However, if a concept is considered essential to the continuity of a topic or has great theoretical significance, its inclusion without adequate evidence could be acceptable, provided its hypothetical nature is emphasized. Furthermore, such topics may be used to illustrate hypothesis and model making as a major part of scientific enquiry.

Synopsis of the Basic Courses

It is not possible at this stage to provide a full synopsis of the courses, but the following is a brief statement of the rationale around which they have been developed.

1. The Living Community (2 weeks)

Students will have their first experience, at this level, of plants and animals in natural or simulated 'field' situations, where the organisms can be seen in relation to each other and their surroundings. A few habitats are examined. We have three major aims at this early stage:

a. To focus attention on variation and patterns in biological material and methods, including those involving statistics, description, identification, and making records.
b. To provoke questions and guesses which will be dealt with more fully later. Some long-term investigations may arise out of this course.
c. To make students consider problems of communication amongst biologists and the nature of biological explanations.

At the outset we wish to encourage the acquisition of first-hand experience of organism in natural communities which will be invaluable later on.

2. The Maintenance of the Individual Organism (18 weeks).

The object of this course is to study the activities of individuals and their associated structures drawn from a small number of species. Such studies will require the learning of biochemical, physiological, and anatomical techniques, needed also in other courses. The emphasis throughout is on the individual organism and its constituent parts. Some related applied topics are: nutrition and diet; food production; the heart-lung machine, the artificial kidney; selective weedkillers.

3 The Organism in elation to its Environment(10 weeks).

This course will depend upon the examination, in Course I, of a few local communities such as those inhabiting waste ground, paths, lawns, and acquaria, and the fundamental questions concerning distribution that emerged from it. In the autumn it will be necessary to collect certain seeds for growth later on and to start a few of the long-term investigations which are needed in connection with ecology and genetics.

In the summer term we shall be concerned mainly with single species of plants and animals and their study in relation both to their physical and biotic environments (including a study of social behaviour in animals).

Related, applied topics may be: conservation, biological control; agriculture; horticulture and fishery practices and human population problems

4. The Developing Organism (10 weeks)

The programme of work will be designed to cover the different levels of developing systems; biochemical, cellular, tissues, organ, organism, and the formative processes of growth, differentiation, and morphogenesis. It will also show how development proceeds from the general to the particular and how patterns of development vary.

Related, applied topics may be· production of economic plants and livestock; plant and animal breeding, human heredity; biological hazards of radiation and control of plant growth. The section will also include a somewhat detailed study of mammalian reproduction. The study of development will be linked to those of physiology, ecology, behaviour, and other topics dealt with elsewhere. Other courses are also being devised.

Projects

Individual project work will be undertaken by all students and can be carried out at any appropriate time, but it is likely that terms 3 and 4 will be most suitable. It is allocated a total of 40 periods.

Long-term Class Practical Work

Some class practical work will extend over several weeks, e.g., breeding experiments in genetics. A total of 60 periods is allocated for such work and any extra unscheduled activities. This amounts to 12 periods per term or, roughly 1 period a week. Work on long-term class practicals will take up say, two-thirds of this time.

School Trials

During the academic year 1965-66 teaching materials were prepared and trials of these are now taking place in forty-eight schools grouped in certain areas of England, Wales, Northern Ireland, and Scotland. Local Education Authorities and School Governing Bodies have generously financed the provision of equipment and other materials needed for the trials.

For evaluation purposes it is necessary for the schools to take the course in a fixed order. However, it is intended that the final scheme should be flexible and allow teachers a great deal of room for manouvre and using their own initiative.

Briefing Meetings

The teachers taking part in the trials were briefed at a conference held at Loughborough University of Technology in August 1966. Meetings will also be held in Sheffield College of Education at Easter 1967 and at Southampton University in July 1967. These gatherings will also provide feedback information on the work so far and an opportunity for teachers and others to discuss their reactions to the scheme

In addition, regular meetings are held in each of the trial areas.

Evaluation

The work of the scheme is being evaluated in a number of ways: first through the regular assessment by teachers of the way the work is faring in their own school, second, through meetings as outlined above, third, by visits of small teams of observers to the schools; fourth, by a number of research biologists, teachers, and others reviewing the publications, finally, by examinations which are currently being devised.

Examinations

Investigations are now under way of the uses of objectives-type papers, open-ended problem questions, and different forms of essay. In addition, methods of continuously assessing practical work are being tested in schools carrying out the trials.

The work on evaluation and examinations is being closely integrated and an Evaluation and Examinations Committee has been set up. This includes representatives from each of the Examination Boards.

Publications

The Students' Laboratory Guide and Study Book provides a series of open-

ended investigations and instructions regarding procedure.

A Students' Problems Book is used to extend the results obtained in the laboratory and to provide secondhand evidence or appraisal.

Pamphlets for students are used to introduce topics to provide background reading, and to review themes.

A Teachers' Guide is intended to supplement the students' material and to suggest lines of approach in teaching.

A teachers' Laboratory Book lists the equipment needed for each practical exercise, suggests sources of living material and provides other technical information.

The work is supported by the use of 8mm film loops and 16 mm sound film.

THE NUFFIELD FOUNDATION A-LEVEL PHYSICAL SCIENCE COURSE

This course is being developed as an integrated approach to physical science in the sixth-form and is intended to be a study in its own right as well, suitable for those wishing to proceed to further study in physics, chemistry, and technology. This subject will occupy a time allocation of only one full subject and consequently a pupil besides studying mathematics may also have the opportunity of serious study in biology or a non-scientific subject.

The General Form of the Physical Science Course

The flow diagram gives an overall picture of the ground we think it practicable to cover. We are encouraging quite considerable variations of timing, order, and emphasis between one school and another. Moreover, the varying backgrounds of the pupils means that a particular topic may have to be treated very thoroughly in one school while a similar thoroughness would produce boredom in another school The arrows show how each topic can be cross-linked with others, and how the actual sequence of topics may be varied. For example, the study of simple harmonic motion might arise as a result of experiments with oscillating mechanical systems, observations on a suitable electrical circuit, from an examination of the ways in which molecules—may store energy, or from a consideration of the projection on a diameter of a body moving in a circle with constant angular velocity. Granted these differences of detail and timing, the general framework of topics and ideas is likely to be somewhat as follows.

In the first lesson or so, the pupils are invited to do quite simple things with a variety of materials. They might be asked to observe the extension of metal springs or rubber bands when loaded; the height of rebound of metal or rubber balls dropped on different surfaces, the effect of temperature on properties — for instance, the increase in elasticity of a lead spring at liquid oxygen temperature; the reactions between various substances. In these early lessons it should become plain to the pupils that they are going to be concerned with the properties and chemical reactions of materials, and with the interactions of materials with energy and with radiation.

Throughout the subsequent development we shall stress the fact that be-

cause real materials have to be used in the study of physical and chemical behaviour, the relationships predicted from idealized models are subject in practice to quite definite limitations. In quantitative work it will often be necessary to use equations appropriate to ideal situations, but attention will always be drawn to their practical shortcomings. We shall try to bring the pupils to see these, not as tiresome 'inaccuracies' but as means of penetrating deeper into the real nature of the physical world.

The experience of the early lessons suggests three possible lines of advance. In the first, some of the basic ideas of motion, force, momentum, and energy are studied. A precise meaning for such terms as velocity and acceleration is soon needed. Pupils are encouraged to consider the results of their experiments in the light of such questions as: 'what is meant by the velocity of a body subject to acceleration?' 'How does the value obtained for it by dividing a distance by a time vary, as the distance or time interval is made smaller, and what is the significance of this variation?' By considering such questions pupils are given a physical idea of the meaning of differential coefficients, and begin to appreciate the power of the calculus. Force, momentum, and energy are studied in the context of Newton's laws, and questions are raised, the answers to which often have to be deferred 'Why is the relationship between stress and strain different for a metal wire and for a piece of polythene,' 'Kinetic energy can be converted into potential energy – for instance at the moment of collision – but how is it actually stored before the bodies rebound from one another?' In order to answer such questions it is necessary to consider the microscopic structures of the materials concerned. For solids and liquids little progress is possible until something is known of the arrangements of the atoms of molecules present, but for gases there is no such difficulty The relationship already derived between force and change of momentum from experiments with microscopic systems is now applied to the collisions of gas molecules with the walls of the containing vessel. In the development of the simple kinetic theory of gases, there is a first intimation of the importance of statistics in dealing with large-scale systems, and of the meaning of temperature

The second possible line of advance is a consideration of phase changes, and the properties of the gaseous state. The P-V-T relationships of gases are investigated experimentally, and interpreted in terms of the kinetic theory. 'Deviations from ideality' are considered in terms of the finite size of molecules and of the actual forces between them. The conditions under which the equation $PV=nRT$ can be used are examined, and it is then applied to a determination of the number of moles of gas present, and hence of molecular weights and formulae. Consideration of the equilibrium between a condensed phase and its vapour provides an introduction to some of the general features of equilibria and leads to a description of the phase relationships of pure compounds. A preliminary correlation of the heat effects of phase changes with the chemical nature of

the compounds concerned is attempted. Solid–liquid vapour equilibria for systems containing more than one compound are studied on the basis of Raoult's law, and further methods of counting moles emerge. This section on gases and phase equilibria thus serves several purposes. It gives practice in the handling and purification of various compounds. It begins to show something of the relationship between chemical constitution and physical properties, and how large-scale phenomena can be explained in terms of the motions of molecules and the forces between them. It gives ways of counting moles and thus of finding stoichiometry and formulae

Thirdly, a survey is made of the reactions of a group of chemical elements (conveniently, those of the second short period) and of their compounds. The reactions of these elements with each other and with such reagents as water, acids, alkalis, oxygen, and chlorine are studied, probably with different members of the class carrying out different reactions, and then pooling their results Reactions of the oxides and chlorides of the elements are also looked at. Physical properties of both the elements and their compounds are either determined or obtained from tables. (Properties such as hardness, melting and boiling points, electrical conductivity, heats of fusion, and vaporization, are included). All this raises questions about differences between metals and non-metals, the relationship between properties and structure, and about stoichiometric relationships and formulae. These questions are discussed in terms of a simple model of the atom, in which there are groups of electrons around a positive nucleus, with rare gases having stable groups. Several important types of reaction are now considered in more detail in terms of this atomic model. Reactions between acids and bases are followed by measurements of electrical conductivity and of heat evolution, and the results interpreted in terms of a transfer of protons between molecules or ions with unshared pairs of electrons. Further reactions, in which an acid or a base is liberated from one of its salts by a stronger acid or base, are then seen to involve a competition for protons between two donor molecules or ions The formation of complex compounds between metals and ligands is studied experimentally, and seen to involve a smliar transference of acceptor species (now metallic cations) between donor molecules or ions. And redox reactions are shown often to be best regarded as a transfer of electrons from one atom, molecule, or ion to another. The relative strengths of oxidizing and reducing agents can be defined in terms of a competition for electrons, just as the relative strengths of donor species might be assessed through the competition for protons or cations. For redox reactions, however, the measurement of electrical potentials provides an easy and convenient method of determining these strengths experimentally.

The topics so far described occupy the first term. The remainder of the course will now be outlined in less detail. A study of electricity is suggested, not only by the pupils' previous experience in this field, but by the

close connection between electrical charges and physical and chemical properties suggested by the work already done. Characteristic phenomena occur when electric charges are separated from one another, and charges in motion are identified with electric currents. Particular attention is given to capacitors, use being made of the concepts of potential and energy already encountered in a dynamical context. The storage of energy in a dielectric is recalled later in the course when molecular dipoles are under consideration Current/potential relationships for a number of systems are observed, and explanations either attempted in terms of what is already known, or deferred. Magnetic effects arise when there is relative motion between charges, but the development of the phenomenon of electromagnetic induction is left until later.

The way is now open for a systematic consideration of the evidence bearing on atomic structure. Electrons from heated filaments can be deflected both magnetically and electrically, and suitable arrangements of the deflecting fields enable the ratio e/m to be found. Consideration of Millikan's experiment provides evidence for the particulate nature of electricity and gives a value fore Knowing the Faraday, Avogadro's number can be calculated. The mass spectrometer principle can be understood, and Rutherford's scattering experiments looked at, as evidence for a 'nuclear' atom. Information for chemical properties (periodicity, etc.) and from electron-impact experiments indicates that the electrons in atoms are in definite energy–states. (Spectoscopic evidence will probably be deferred.) The picture of ionic and covalent bonding hitherto used can now be made slightly more precise. The energetics of the formation of ionic crystals is discussed in terms of ionization energies, electron affinites, etc., and molecular polarity considered on a simple electrostatic basis. Deductions about molecular geometry are made from the principle of repulsion of electron-pairs, and packing arrangements for spherical ions explored with the help of polystyrene spheres.

The properties of real gases, especially critical phenomena, show that both attractive and repulsive intermolecular forces exist, that is, when two molecules approach one another, the potential energy of the system decreases to a minimum, and rises sharply as they come still closer together. Information about the shape of such curves is obtained from surface tensions and heats of vaporization, and such properties as tensile strength, thermal expansion, etc., are then discussed. In this preliminary treatment of the connection between large-scale properties and intermolecular forces, no account is taken of the effect of the specific structural features of solids. This will be examined later, when something is known of the evidence for solid structures.

Chemical equilibria are considered in detail. Some of the guiding principles have been suggested by previous work on phase equilibria, on redox potentials and on the idea of a competition for protons or cations between bases or ligands. The formal equilibrium relationship is stated without proof, and is verified by measurements on

suitable systems. Its application is illustrated mainly by systems involving ions—in particular, by acid-base systems.

Previous experimental work on cell reactions, phase changes, and equilibria generally, makes possible an elementary treatment of the factors which determine whether or not a physical or chemical change can occur. The unorganized nature of thermal energy is discussed, and the concepts of randomness or entropy and free energy are introduced. It may then be possible to deal briefly with the relationship between heat and temperature

These preliminary and introductory studies on the thermodynamic feasibility of physical and chemical processes make it plain that without further data, no information is obtainable about the rates of such changes or about atomic or molecular mechanisms. The factors which govern the velocity of chemical reactions are therefore investigated experimentally. A detailed treatment of the results for a few selected reactions shows how such measurements can, in general, give information about reaction mechanisms in terms of the movements and energies of the molecules concerned.

Both the movements of macroscopic bodies and the possible motions of molecules, suggest a study of motion in a circle and of angular momentum and energy, and this can lead to a treatment of simple harmonic motion. But the kinetic and potential energy associated with a single harmonic oscillator also has significance for molecular dynamics and heat capacities. Electrical oscillations are considered, and an examination of vibrations in coupled systems shows how energy can be transferred by wave motion These various lines of investigation converge in an extended study of electromagnetic radiation. Interference and diffraction and polarization properties are observed for various wavelengths, but the photoelectric effect indicates that radiation also has particulate characteristics. Observations of the absorption and emission of radiation of various wavelengths are related as far as possible, to the accompanying atomic and molecular processes It is then seen, in principle, how the results of such measurements can be used to derive information about the structures and dynamics of molecules and of crystals.

The ideas of bonding, structure, equilibrium, kinetics, energetics, etc., so far developed, are applied to the detailed experimental study of one or two elements and their compounds. We believe it better to employ the available time in this way, than to attempt a superficial survey of a larger number of elements. This study involves the preparation of compounds in the various oxidation states of the element, and the determination of their compositions and properties. Rates of reactions are measured and where possible are related to mechanisms, and the relative stabilities of different oxidation states are assessed. In this way, (for instance, by studying a typical non-metal and a transition element) first-hand experience is gained of some important types of chemical and physical behaviour.

In order to obtain greater insight into the reactions of covalent com-

pounds and the dependence of their physical properties on structure, it is desirable to deal with series of closely related molecules. For this reason, as well as for its practical importance, much attention is devoted to the reactions and properties of organic compounds. The chemistry of carbon is examined in relation to that of neighbouring elements in the periodic table so as to distinguish the factors which give it such an extensive chemistry Aliphatic and aromatic compounds are studied side-by-side, and the emphasis is on the way in which different types of reagent affect different kinds of bond Practical work is directed to an examination of how equilibrium and kinetic factors determine reaction products under various conditions.

In the later part of the course there is a detailed examination of the relationship between microscopic structure and forces and macroscopic properties, for a selected class of materials such as metals or high polymers.

In all this, practical work is much more important than in conventional A-level courses. In addition, the equivalent of about half a term is given to a specific project. This can be either a small research-type investigation, or the design and construction of a piece of equipment, or the study in depth of a particular part of the course.

School Trials

During 1966-67, the course is being tried in sixteen schools, and work continues on course development, involving the circulation of drafts, general discussion, and consideration of the experience of the schools in teaching the course. We have already had much help from university teachers through their membership of working parties set up to advise on methods of presenting specific topics, and we are at present considering ways in which we can best continue to call on their help and goodwill. The trials schools are submitting detailed reports at frequent intervals on the work done, and each school will receive at least one visit a term from a member of the physical science group There will also be a three-day discussion each term between the physical science group and the teachers from the trials schools. Because of this methods of working, and because work done in later terms of the course must depend on the experience of the earlier terms, we can not at this stage give more than an outline of what we hope to cover.

Most of the trials schools are allowing nine periods a week for physical science, and have arranged for both the the physicist and the chemist concerned with the course to be jointly timetabled with the physical science set for some at least of these periods. It is hoped that each teacher will thus become familiar with unfamiliar parts of the course, and that experience will be gained with 'team teaching'.

Apparatus and Teaching Aids

Experiments are being devised and apparatus developed, in cooperation with the groups producing the Nuffield A-level courses in physics and in chemistry. Arrangements are also being made for the joint production of film loops and programmed texts.

We cannot give a meaningful estimate of the cost of establishing the course, because this will depend so much on the existing equipment possessed by a school. We are, however, determined to keep this cost as low as possible. We feel we can reasonably ask schools to purchase instruments which will be used time and again in the course (e.g. a D.C. amplifier or a photoelectric colorimeter), but not apparatus which will be used only once or twice.

The Conduct and Form of the A-level Examination in Physical Science

The Cambridge Local Examinations Syndicate is to be responsible, on behalf of all the examining Boards, for the conduct of A-level examinations in physical science, in 1968, 1969, and 1970. This will be taken by all those who have followed the Nuffield physical science course, regardless of the normal G.C.E. arrangements at the trials schools Of the four examiners, two have been appointed by the Cambridge Syndicate, and two are members of the physical science group. The A-level papers will be set in the light of experience in the schools during the trials A common written test will be taken each term by all the trials schools, and will include new types of questions and questions on topics which may not previously have been examined at this level. The A-level examination will include a 'special' paper but no practical test. The examiners are considering how best to assess the practical work done by pupils throughout the course.

A committee comprising representatives of the Cambridge syndicate and of the other Boards, and of the Nuffield Science Teaching Project, will watch the progress of the trials from the point of view of the G C.E. examining Boards generally

If physical science as an A-level subject gains increasing acceptance by schools and universities, syllabuses are likely to be published by individual Boards. (Both the N.U.J.M.B. and the Cambridge syndicate have already begun to draw up such syllabuses, quite independently of the Nuffield enterprise). It may be however, that the special arrangements outlined above will need to be continued for a year or so after 1970.

Publications in Preparation

It is the present intention of the Nuffield Science Teaching Project to publish the materials produced for all the A-level courses in the summer of 1970

For physical science we hope at present to produce the following books:
1. An introduction and guide to the general philosophy of the course.
2. A detailed teachers' guide, which will include information about apparatus, demonstrations and class experiments, and projects.
3 A compendium of information for the pupil, issued as loose pages or as a book with tear-out sheets. Such material may include straightforward exposition, experimental directions, reprints of portions of scientific papers, etc.
4. Possibly a book of questions and problems.

Certain other materials may be produced and published, in conjunction

with the other Nuffield A-level groups. These may include a book of data, film loops, programmed texts, and background readers.

THE NUFFIELD FOUNDATION A-LEVEL CHEMISTRY COURSE

PRINCIPAL AIMS OF THE COURSE

The chemistry course is based firmly on establishing three concepts of fundamental importance in the study of chemical systems: the Central position of energetics in determining the feasibility and outcome of reactions, the relationships between the structure of substances and their properties, and the unifying pattern provided by the Periodic Table. In choosing material for study, the ability of a topic to illuminate one or more of these concepts has been used as a primary criterion for selection The intention is to integrate as fully as possible the physical, inorganic, and organic aspects, and to emphasize the generality of the physical principles.

A positive attempt is being made to illustrate principles by using, where appropriate, examples from the fields of metallurgy, biochemistry, agricultural science, medicine, and chemical engineering. This is being done partly because the close relationship of the subjects demands it, and partly because pupils can scarcely be expected seriously to consider a career in one of these fields unless they are made aware of their existence and of something of their nature, scope and challenge. For similar reasons, economic effects and social changes which have resulted from developments in chemistry are aspects of the subject with which a sixth form pupil should be familiar. Engendering an appreciation of some of these aspects forms part of the course together with a realization that the pure science of today becomes the applied science of tomorrow.

The body of knowledge which is acquired in the process of undergoing a course is determined by the course content, but the attitudes of mind and the personal qualities which are developed depend upon the teaching methods which are used. In the integrated pattern of experimental work and theory in the chemistry course the experiments are chosen so as to elicit basic principles, and the greater proportion are passed in the form of questions. The pupils are expected to suggest experiments which might lead to answers to the questions, Pupils are led to suggest models by which chemical behaviour may be understood, to suggest consequences of these, and to search for confirmation. The intention is that in these ways, by seeking answers to leading questions, by the planning of experimental work, and bythe forming their own interpretations and conclusions, pupils will be provided with opportunities for developing an inquiring attitude of mind, self-reliance, and imaginative thinking

It will be apparent that the employment of these methods consumes more time than the traditional teaching and learning methods; and a corollary is that fewer items of chemistry can be considered in given time than is done in traditional courses. It is the belief of the teams involved in compiling the course that a greater understanding

and a more inquiring, critical, and self-reliant approach will more than offset the reduction in subject-matter.

If the aims outlined above are to be fully realized in schools some changes in examining methods will be required. These will entail new types of questions and new methods of assessment, particularly of pupils practical ability. Questions to test understanding rather than memory, which encourage critical appraisal of ideas, and stimulate imaginative thinking must appear more frequently in examination papers than has been customary in the past. The framing and testing of such questions is a part of the work of the Project

The Students for whom the Course is Designed

The course is for students of chemistry in the sixth form; but these are very diverse in the uses which they will subsequently make of their sixth form studies. Four principal categories of pupils may be seen. There are the future degree scientists, those who will study the subject at a university or other institution of further education and who may pursue careers in pure or applied science There are those who will continue the study of science in further education, taking professional examinations, some of which are of degree level and which range through the National Certificates, this group covers a wide field of careers, as different as laboratory technicians and nurses A further group consists of future degree-level students, but whose subsequent studies will not be in chemistry; these include students for professional examinations in careers as solicitors, barristers, bankers, chartered accountants, and also those who will study undergraduate courses in such subjects as the social sciences. In addition to these three groups there is a fourth: the increasing number of pupils who spend one or two years in the sixth form and who undertake a relatively short course of futher training after leaving schol, entering a wide range of occupations.

No single sixth form course in chemistry can provide adequately for each of these groups Sixth form studies have a prime responsibility for future degree students, and must give a sound basis for further study at that level, they must provide opportunities for stretching the minds of the most able. But at the same time they have a responsibility to the other groups, particularly those who will continue with a professional training. The sixth form course must provide a suitable preliminary to this, be within the abilities of the pupils concerned, and be seen to be relevant to their needs and interests.

The course must therefore be reasonably satisfying and complete in itself, not one which finds its full realisation only after a further three years of study at a university level. The Nuffield Project attempts to reassess the quality of subject material which is practicable as the content of a two-year sixth form course.

Provisional Synopsis of Course Content

Topic 1. An initial look at the periodic table (3 weeks).

Periodicity of physical properties from graphical representation of data.

Atomic weight and atomic number order. Preparation and analysis of the chlorides of the elements Na to S as indication of trend of chemical behaviour and of stoichiometrical relationships. Extended (largely experimental) survey of chemical behaviour and formulae to include halides, oxides, and hydrides of Periods 2 and 3. Brief historical background to the Periodic Table.

Topic 2. Avogadro's number, and the mole ($\frac{1}{2}$ week)

The mole as and Avogadro number of particles, including atoms, ions, electrons, and molecules

The thin film, oil drop experiment demonstrated and less approximate value for N obtained. N calculated from a radioactivity method, and from the Faraday and the charge on the electron.

Topic 3. The gas laws, and molecular weights (1 week).

Ratios of combining volumes of gases. Avogadro's explanation. The ideal gas equation, $PV=nRT$. Experimental determination of molecular weights of gases and volatile liquids, based on the gas equation.

Topic 4. Oxidation states: Oxidation and reduction (1 week).

Revision of electrochemical series Relative nature of terms electropositive and electronegative. The oxidation state concept. Rules for assigning oxidation states Oxidation state charts. Oxidation and reduction as increase or decrease of oxidation state.

Experimental survey of oxidation states of manganese. Oxidation states and periodicity

Stoichiometry of a redox reaction established experimentally, e.g. permanganate/iron (11).

Topic 5. Atomic structure and energy levels in atoms ($2\frac{1}{2}$).

The nucleus. the work of Geiger and Marsden, Moseley and Rutherford; atomic number. Isotopes. The use of the mass spectrometer in the determination of atomic weights; calculation of atomic weights from mass spectrometer results.

Evidence for the arrangement of electrons in energy levels. demonstration of excitation and ionization of helium by electron impact; class observation of emission of spectra of a range of elements, using direct vision spectroscopes or gratings. Relationship between energy levels and spectral lines; and ionization energy from a convergance limit.

Successive ionization energies for selected elements.

The terms s,p, and d electrons, as representing energy levels; spatial distribution of electrons (but not of p and d electrons).

Radioactivity and the structure of the nucleus. stable and unstable groupings of protons and neutrons.

Topic 6. Periodic Table studies continued, s and p block elements (3 weeks)

Experimental investigation of properties of some compounds of Na, Mg, Ca, Sr, Ba, Al and of the behaviour of ions of these in aqueous solution.

Experimental investigation of properties of some compounds of Na, Mg, Ca, Sr, Ba, Al and of the behaviour of ions of these in aqueous solution.

Experimental investigation of Cl, Br, I, and their compounds.

Interpretation of results of above studies in terms of atomic structure

(including ion charge and ionic radius) and oxidation states.

Stoichiometry of S O –(aq)/ I (aq) reaction derived practically.

Topic 7. Energy changes, and bonding (2½ weeks).

Experiments to indicate the specific contributions of individual bonds to over-all energy changes: enthalpies of combustion of a homologous series of alcohols, enthalpies of neutralization.

Enthalpies of formation and bond energy terms; discrepancies between predicted and experimental values for enthalpies of formtaion leading to structural interpretation, e.g. strain in cycloalkanes, structure of benzene.

Born-Haber cycles, lattice-energy.

Topic 8. Structure and bonding (2½) weeks

X-ray diffraction: the Bragg equation, ripple tank and optical analogues of X-ray diffraction, as demonstrations. Some crystal structures to illustrate co-ordination number. The Avogadro Number from X-ray evidence.

A Lewis-Langmuir approach to the stoichiometry of compounds, using electroncounting, ionic and covalent bonds; the gradation between ionic and covalent bonds; polarization. Electronegativity. The metallic bond.

Shapes of molecules, in terms of repulsion between bonds and lone pairs of electrons.

Overlap of electron clouds as providing the binding force in covalent bonds. The bent bond approach to multiple bonds. X-ray evidence for the symmetry of the acetate ion and the benzene ring, delocalization of electrons; stabilization energy of benzene.

Topic 9 Carbon chemistry-Part 1 (8 weeks).

Chemical and physical stages in the establishment of structural formulae, the mass spectrometer in the analysis of carboncompounds The ideas of alkyl groups, functional groups, and isomerism presented as the results of structural studies.

Hydrocarbons-Experimental study of the effects of changing shapes of molecules on physical properties of hydrocarbons. Experimental study of the chemical properties of some hydrocarbons, including hexane, cyclohexane. cyclohexene. and benzene. Oil as a source of hydrocarbon fuels and petrochemicals

Alcohols-Reactions of ethanol studied expermentally; homolytic and heterolytic fission introduced in discussing the reactions. Laboratory preparation of some compounds from ethanol. Other alcohols. Industrial imporance of alcohols

Phenol-Properties studied experimentally. Increased acidity of the –OH group when attached to a benzene ring, its explanation in terms of delocalization of an oxygen lone pair of electrons. Preparation of phenyl benzene ring illustrated by ease of bromination and nitration

Carboxylic acids-Experimental study of the reactions of acetic acid. and the preparation of some compounds from it. Increased acidity of an –OH group when in the carboxylic acid group, explanation in terms of the distribution of electrons. Other carboxylic acids.

Alkyl halides, aryl halides, and acyl halides–Experimental study of the properties of the alkyl halides, includ-

ing the influence of the alkyl group on the rates of hydrolysis and dehydrohalogenation. Lack of reactivity of chlorine in chlorobenzene; explanation in terms of delocalization of chlorine lone pair. Influence of –Cl on the benezene ring, mechanism of nitration and bromination. Properties of acyl halides studied experimentally. Uses of organic halogen compounds.

Alkenes-Industrial production. Properties studied experimentally. Addition, substitution, and elimination reactions compared. Uses of alkenes and polyalkenes. Ketones and aldehydes-Differences between addition to alkenes and addition to a carbonyl group found experimentally; nucleophilic and electrophilic attack. Identification of a carbonyl compound by preparing a derivative.

Amines-Experimental investigation of 1-aminobutane and aniline. 2-aminobutane, optical isomerism of compounds containing one asymmetric carbon atom.

Compounds containing two different functional groups-Experimental study of glycine and other amino-acids; paper electrophoresis. Biological importance of amines and amino acids.

General methods of preparation—This covers all the classes of compounds studied

Problems in synthesis—This includes experimental work. Stages in elucidating the structure of a complex substance Qualitative discussion includ ing chemical evidence, physical evidence, and confirmation by synthesis.

Topic 10. Phase equilibria, and distillation (2½ weeks).

Experiment to obtain vapour pressure/temperature relationship for liquid/vapour system, plotting log vapor pressure against 1/T, and connection with Hvap, Discussion of complete phase diagram for a one component system. Van der Waal's forces.

Experimental determination of boiling points of liquid/liquid mixtures to reveal ideal and non-ideal behaviour

Non-ideality interpreted in terms of intermolecular bonding (in hydrogen-bonded systems).

Experimental determination of some enthalpies of mixing, as further evidence of intermolecular bonding. The implications of these ideas for distillation; experiment to determine the composition of liquid and vapor during the distillation of a non-ideal mixture.

Topic 11. Hydrogen bonding (1 week).

Anomalous properties of hydrides in Groups IVB, VB, VIB, and VIIB in the periodic table.

The structure of ice, and of water.

An approximate value for the strength of the hydrogen bond derived experimentally from enthalpy of mixing.

Further examples of hydrogen bonding in organic and inorganic systems.

Topic 12. Solvation (1½ weeks).

Experimental study of systems involving anhydrous salts and water; enthalpy changes; changes in total volume.

Similar studies with non-aqueous solvents. Ion-solvent complexes.

Topic 13. Equilibria: gaseous and ionic (5 weeks).

Qualitative experimental study of equilibria. Quantitative experiments leading to establishment of equilibrium law. Application of law to gaseous

equilibria.

Experimental establishment of the equilibrium law for a system involving ions.

Experimental studies of redox equilibria arising from electrontransfer in element/ ion and ion/ ion reactions. Concentration cells. Electrode potential measurements. Standard redox potentials, use to predict possible reactions, checking predictions by test-tube experiments.

Acid/base equilibria arising from proton transfer. Experimental study of pH and its measurement, strengths of acids and bases, titration curves, buffer solutions, acid/base indicators.

Topic 14. Some d block elements (2 weeks).

Experimental study of variable oxidation states (manganese has been dealt with earlier, in Topic 4) Complex formation in solution (link with Topic 12); stability constants (link with Topic 13). The transition elements and their compounds as catalysts. Some alloys and their uses Transition element compounds in living organisms.

Topic 15. Reaction rates ($4\frac{1}{2}$ weeks).

Qualitative experimental study of the reaction between permanganate ions and oxalate ions to indicate effect of conditions on rate, autocatalysis, intermediate steps in reaction, and to lead to speculation about a possible mechanism

Detailed experimental study of a first order and a second order reaction to bring out the essential features of these, including relation between half-life time and intial concentration.

Experimental investigation of a reaction in which the rate law is not related to the stoichiometric equation.

Simple collision theory of reaction rates, inadequacy of this, activation energies and transition complexes, function of catalysts in increasing reaction rate. Experimental study of some aspects of catalysis, e.g. photo catalysis, enzyme action.

Topic 16. Equilibrium, free energy and entropy (3 weeks).

Experimental study of a range of spontaneous reactions (including some which are endothermic). –H value not always only factor determining spontaneity. Spontaneity and value equilibrium constant (K) Plot of the log K against I/T to introduce relationship 2.303 log K=AH/ RT+constant.

Work done during energy transfer between system and environment for mechanical systems (where limiting thermal energy equals, in principle, limiting optional work). Limiting optional work as measure of changes from cell e f m measurement (G · nef) G and prediction of spontaneity (arising from use of E values for this purpose in Topic 13) Standard free energies of formation and their uses.

Experimental evidence to support the relationship G= H—T constant. Hence G should not always equal H in chemical systems (contrast with mechanical systems).

Experimental measurement of G and H for a redox reaction. Identification of constant in above expression with entropy change (change in number of ways system can hold a given amount of energy). Units for entropy G= H—T S Absolute entropy values. Methods of measuring entropy.

Values of H and S relatively in-

sensitive to temperature change (link with H and bonding studied earlier). Discussion of relative magnitude of G, H and T S factors for a range of representative reactions. Limitations of use of G values for predictive purposes since they give no information about the rate at which a change can proceed.

Topic 17. Carbon chemistry-part II (4 weeks).

Natural compounds—Examples of the range of types of compounds present in nature including among others representative fats, carbohydrates, and proteins, vitamins, antiteins etc. Experimental hydrolysis of proteins and the separation and identification of the resulting amino-acids chromatographically. Structures of proteins, and the importance of hydrogen bonding. Template mechanism of synthesis of proteins. Breakdown of proteins in the body to urea. Wool and hair as proteins.

Synthetic compounds—The polymerization of alkenes, including an experimental investigation of the polymerization of styrene. Experimental investigation of the physical and chemical properties of the polymers and their relation with structure. Distinction between thermoplastic and thermosetting plastics.

Synthesis of substitutes for natural products—These are illustrated by an experimental study of the detergency of sodium salts of carboxylic acids and its relation to structure; preparation of synthetic detergents.

Topic 18. Further periodic Table study (2 weeks).

Treatment will depend to a large extent on the elements selected but will included consideration of stiucgui-nctiy, structure, energetics and rates. Where appropriate, attention will be directed to technological, economic, and social aspects of the selected elements and their compounds.

Suitable elements for study include nitrogen, phosphorous, and sulphur.

Topic 19 Special Studies (7 weeks).

This section is intended to provide opportunities for using again, in new contexts, the principles studied earlier in the course and for seeing something of the scope of neighbouring subjects which are based on chemical principles. The intention is also to show pupils something of the applications and chemical engineering of the subjects, and of their social and economic effects There will be an opportunity for pupils to undertake a project. Two topics are to be selected from the following list:

Metallurgy
Chemical Engineering
either Biochemistry or Food Science
Instrumental Methods of Analysis Ion Exchange Processes
Natural and Synthetic Fibres.

Total Content and Time

A week is taken to contain seven periods of forty-five minutes each and two hours of homework. A two year sixth form course may be taken to contain 53 weeks which are available for the study of new material, and a few weeks for revision before the A-level examination.

The present tentative course overruns the time available by a few weeks,

and some further reduction in content will be necessary.

School Trials

Trials of the material produced during the first year of the Project's work began in September, 1966. Twelve schools, selected to give a reasonable range of pupil ability, type of school and geographical distribution, have agreed to allow one or more of their sixth form sets to follow a complete two years course. In all some 259 pupils are involved in these trials. They will take a special A-level examination in the summer of 1968.

Publications being prepared

1. *Teachers' Guide*: This suggests lines of treatment for the topics in the course. In its general plan this is similar to the corresponding publication of the O-level project.

2. *Pupils' Guide to Experimental Investigations.*

3. *Data Sheets:* For use in discussing problems and ideas arising from experimental work, and to provide information needed in answering questions set for homework and in examinations.

4 *Information for Pupils:* This provides a certain amount of textbook material that does not appear in existing school texts. It also discusses applications of chemical principles to related fields of study, uses of substances studied in classwork, extracts from original papers and other published material, and general background reading designed to provide new fields of interest.

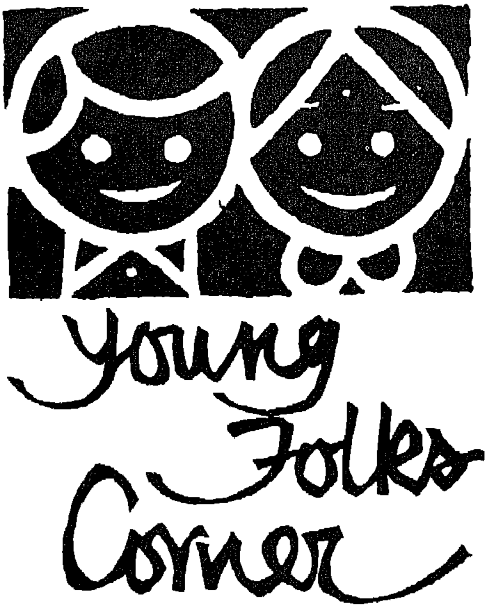
5. *Specimen Problems:* This will cover all aspects of the work done, not being confined to numerical problems only. A range of questions of different types (open-ended, short answer, objective, etc) is provided.

In addition to the above items, plans are being made for the production of a series of films and film loops to illustrate areas of the subject best treated in this way. Consideration is being given also to the publication of a textbook for use by pupils.

Working Parties

These have been set up to serve all the physical Sciences projects. Their composition varies slightly but, in general, each includes a university professor, a university lecturer, a school teacher, and a member of the Headquarters team. Similar Working Parties are being established to deal with each of the Special *Studies in Topic 19.*

The purposes of the working parties are to provide expert advice on content and possible methods of presentation, and to ensure that the approach adopted in the course will be suited to the needs of future university students.



Great Dutch Pioneers of Scientific Research: Hendrik Antoon Lorentz

From Light Phenomena to the Theory of Relativity – Part I

IT is not everyone who learns to use a logarithm table at the age of ten, lives to be 75 and, at that age, is able to look back on professorships spanning more than half a century Such men are few, and they belong to a select band of scientists. One such man was Hendrik Antoon Lorentz. Born in 1853 at Arnhem, he obtained his Doctorate at the age of twenty three with a thesis on the reflection and refraction of light. Two years later he was teaching theoretical physics at the famous university of Leyden In addition to perfecting the "classical" physics, heralded by the works of Galileo, Huygens and Newton, Lorentz achieved international fame by laying the foundations for physics as we understand it today including the theory of relativity developed by Einstein and modern nuclear theory. His method of calculating tidal currents and flood tides –which was of inestimable value in the plan which resulted in the damming of the Zuyder Zee–is still in use.

Let us make a journey through the land of adventure in which Lorentz set out to lay a path of science almost a century ago; a land of labyrinths and *cul de sacs*.

His thesis, written in 1875, was immediately recognized as a work of importance. In it, he lent great support to Maxwell's theory that light consisted of electromagnetic vibrations moving through what was known as the ether indeed Lorentz employed this theory as a basis for calculating the laws governing the reflection and refraction of light Twenty years later, he developed Maxwell's theory into what we know as the electron theory. He envisaged charged atomic particles which, when caused to vibrate, acted as a moving charge and thus radiated electromagnetic vibrations; in other words, light. And he deduced that a moving charge–which was, in fact, an electrical current–would emit rays of a somewhat different wavelength if subjected to the influence of a magnetic field. This theory, postulated by Lorentz when he was 42, was proved by Prof. Pieter Zeeman of the university of Amsterdam a year later. Zeeman placed a sodium lamp between the poles of a powerful electromagnet; he found

that when current was applied to the magnet, a slight variation in the wave-length of the light emitted by the lamp could be observed. With the aid of this Zeeman effect, as it became known, Lorentz pointed the way to the discovery of the charge and mass of the ion or electron—the charged particle of the atom which formed the basis of his theory. We now know that the charge is negative and that the mass is 1/1834 of that of a hydrogen atom.

The work of Prof. Zeeman is described in another book in this series. The theory developed by Lorentz and the tests carried out by Zeeman led to the making of the first model of a hydrogen atom, consisting of a positively—charged nucleus and a negative electron 1/1834th its size. Lorentz and Zeeman were jointly awarded the 1902 Nobel prize for physics for their work in this field. The atom model was gradually improved, the one developed by Niels Bohr still being of value for many purposes.

Lorentz's gift for presenting the most complicated problems in a plain and intelligible manner enabled him to excel as a tutor; by the same token he was a born chairman. It is said that he once gave an explanation of the theory of relativity to a foreign colleague in the presence of Einstein, and that when he had finished Einstein remarked that he had never before understood the concept of relativity so well. In order that the utmost benefit might be derived from his exceptional powers of teaching, he was made a professor extraordinarius on reaching the age of seventy—at which age professors are expected to retire—and was thus able to continue giving lectures. This he continued to do until his death five years later.

Hendrik Antoon Lorentz was known and admired through out the world. He presided over innumerable international congresses, and gave many lectures abroad, including series at Columbia University in New York, the College de France (1915), and at institutes in Pasadena, California, etc. After the First World War, he threw himself heart and soul into the task of bringing about the restoration of international scientific relations

With his death in 1928, the world lost a figure of examplary modesty, kindness and irrepressible spirit and humour; but his scientific achievements have lost none of their significance.

His electrons theory, developed upon the work of Maxwell, paved the way to our present nuclear theories. His views on the nature of light led him to conclusions eventually used by Einstein as a foundation for his theory of relativity Thus, the Dutch physicist Lorentz can be considered a scientist of our day even though he was born more than a century ago.

Courtesy. Radio Netherlands

AUTOCRAT OF THE GALAXY

Jan Hendrik Oort

A colleague of Professor Jan Oort is said to have remarked, "If you speak to him on the telephone, you have to listen very carefully because he speaks so softly. If the subject of the conversation is astronomy, listen twice as carefully and you'll hear one of the greatest experts of our time thinking aloud." It is also said of Oort in professional circles that he is so clever that he doesn't even know how many honorary degrees have been conferred on him; this is probably the only joke concerning the man who is in circulation.

Oort was twenty six years old when he obtained his doctorate, and he had already spent two years as a research assistant at the Yale university observatory in Newhaven, Connecticut. In 1926, the year in which he graduated, he was appointed to an external teaching post at Leyden university. At thirty, he became a lecturer, and five years later, was Assistant Director of the observatory in Leyden. At the end of the last war he assumed the combined post of Professor and Director of that establishment.

In Holland, Oort was the driving force behind the development of a new science, radio astronomy. Luck and a love of walking among the dunes combined to make him the honest finder of the first piece of equipment used for observing signals from outer space: an abandoned dish aerial, formerly part of a German radar station.

In 1956, Queen Juliana conferred an honour on Jan Hendrik Oort. The presentation was made in the small village of Dwingelo, in the East of Holland, the spot chosen for what was then the largest radio telescope in Europe. The observatory there was largely a result of his initiative and effort.

What else does humanity owe to this man? It would be quite impossible to list all his achievements in a career spanning more than forty years. If we must choose one outstanding contribution, that must surely be Oort's work in unveiling the mysteries of the structure of the Milky Way.

Just as, four hundred years earlier, Copernicus put forward the theory that the sun, and not the earth, was the centre of our planetary system, and that the planets rotate around the sun in different orbits and at different speeds, so

did Oort proceed to show that the Milky-Way—of which the sun is but one of the hundred thousand million components—rotates around its centre, and that the stars situated at a great distance from the centre travel at a slower speed than those closer to it. The Oort Constants is the name given to a certain combination of forces which govern therotation of the Milky Way. Similarly, his work has made it possible to chart the spiral structure of the galaxy and to study it in detail. It is now possible, for example, to calculate that the sun and the plants in the solar system describe a vast orbit around the the centre of the Milky Way—an Orbit which takes two hundred million years to complete.

For his discoveries in this field, and his contribution to radio astronomy, Prof Oort was awarded the 1966 Vetlesen prize, an American award, which is regarded by equal to Nobel Prizes in other sectors of learning. Oort does not typify the modern scientist, bustling with efficiency and qualities of leadership, equally, he does not conform to the outmoded vision of absent-mindedness, long hair, stained clothing and dangling shoelacas. His study at the Leyden observatory is a model of neatness.

Its occupant is always attentive, but his quiet, sometimes hesitating voice suggests a lack of self-confidence: he is not, however, a man gives to gesticulation. In his lectures, he frequently gives the impression that something he has said flashed into his mind like a spark a second beforehand. Tall in stature, his bearing is suggestive of the ascetic. He has great powers of concentration, but whether the occupation of the moment be playing the piano, indulging in a game of table-tennis in the Meridian Room of the observatory, long-distance skating or admiring a painting, he does not create an impression of being an impassioned slave. Jan Oort is a man of moderate habits. He was born in 1900, the son of a doctor Unlike so many astronomers, he was not gripped by the wonders of the heavens as a boy He was already a student of mathematics and physics at Groningen university when he was moved by his contact with another great Dutch astronomer, Prof, Kapteyn, to apply himself to studying the stars. He has frequently been approached with offers of a professorship on the other side of the Atlantic But he has always declined. He is loyal to Holland, and to Leyden in particular But his scientific reputation is not bound by any national frontiers. The American Journal 'Look' once published a list of the hundred greatest contemporary contributors to politics, science and art. There was only one Dutchman on that list, and his name was Jan Hendrik Oort.

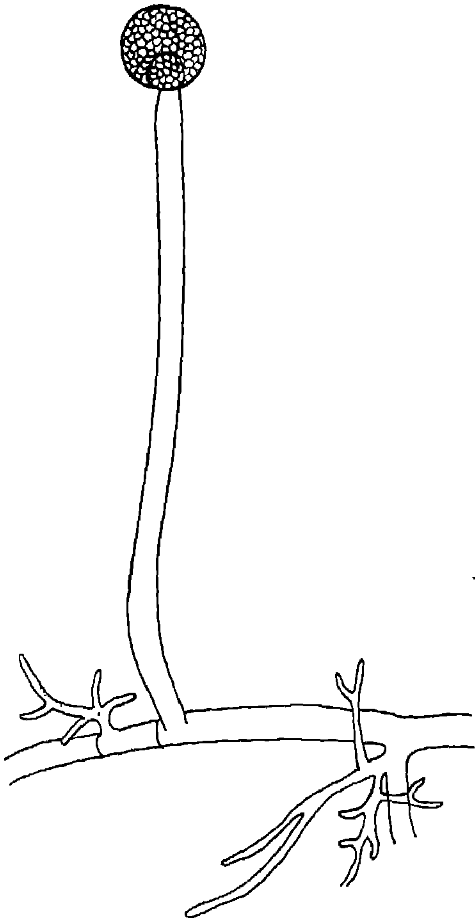
Courtesy. Royal Netherlands Embassy, New Delhi.

Bread Mould

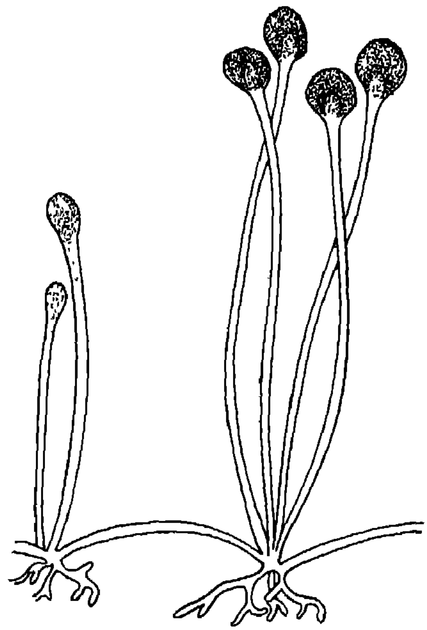
M. Lakshmanan
Department of Science Education,
N.C.E.R.T.

FOR some unexplainable reason the common phycomycete *Rhizopus nigricans* has been known as 'bread mould.' The implication of this common name is often misleading since many filametous fungi besides R. *nigricans* grow on bread and are mainly responsible for the spoilage of bread. Occasionally yeast and bacteria may also be involved. This fact is known since 1885 when Smith associated *Aspergillus glaucus* and *Mucor mucedo* with 'musty' bread. Herter and Fournet in 1919 reported in addition to *R. nigricans* eleven other species of fungi from the genera *Aspergillus, Penicillium, Mucor, Rhizopus* and *Oospora*, A stray case of *neurospora sitophila* as the sole cause of break spoilage is also known (Reed, 1924). In our own experience species of *Aspergillus* and *Penicillium* have been most commonly associated with moldy bread. It is of course a well known fact that *R. nigricans* grows on bread every readily when it is inoculated and put in a moist chamber at the right temperature. But many other fungi also behave the same way. Our knowledge on moldy bread so far does not indicate *R. nigricans* as the principal organism associated with bread spoilage. Should we still perpetuate the botanical folklore of calling *Rhizopus nigricans* as the bread mould?

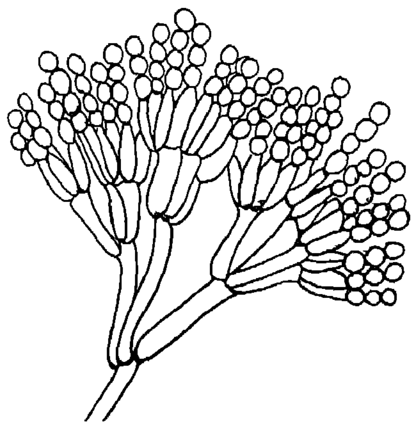
Whatever may be the organism(s) that spoil bread the baker has a real problem trying to control mould growth for at least a period of 96 hours the 'freshness' period of bread. Bread is sterile when it comes out of the even and the mould spores settle on it during the slicing and packing operations. Ultraviolet irradiation while slicing the bread has reduced mould growth but does not put off the moulds completely (owen, 1932) Acetic acid when incorporated in bread or applied as a weak solution (vinegar) on the surface of bread prevented or delayed the development of mould. Kirby and others (1935, 1937) have found that fatty acids are more toxic to fungi growing on mould than mineral acids or organic acids such as lactic, citric, tartaric and maleic. The most widely used mould inhibitors of today,



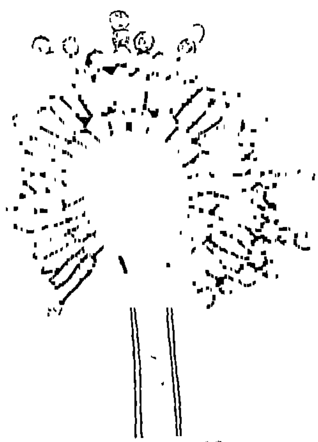
MUCOR HIEMALIS



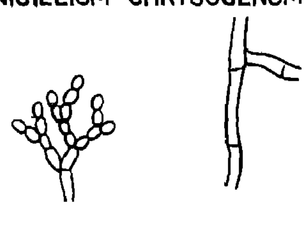
RHIZOPUS NIGRICANS



PENICILLIUM CHRYSOGENUM



ASPERGILLUS



NEUROSPORA SITOPHILA

are sodium and calcium propionates which go by the name 'mycoban'.

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Science Notes

A Revolution in World Communications

Improved communications have traditionally had the effect of shrinking the world, making it as easy over the years to speak to the other hemisphere as it used to be to the other side of the village street.

And technological advances designed to meet growing demand for communications have themselves stimulated demand still further so that world communications traffic has grown at a phenomenal rate.

But over the past few years one advance in particular—the communication satellite—has begun a revolution in communications that is producing new applications, new markets, new possibilities almost every week.

New Internationalism

Television coverage of news events in the United States, received live on the other side of the world as they happen, is now a familiar experience of millions of viewers.

Behind this wonder of science that is now taken for granted lies a new internationalism—Not only in the actual process of communication but also in the planning and operation of the complicated systems involved and in the manufacture of spacecraft, ground stations and associated equipment.

No fewer than 61 countries are now members of the International Telecommunications Satellite Corporation (INTELSAT), the world body which is planning and has begun to implement a truly global network of communications by satellite.

INTELSAT is concerned only with planning and acquiring the "space segment"—that is, the satellites—leaving individual countries to plan and build, or buy, their own earth stations

Britain's experience in the design and construction of communication satellite earth stations stems from her pioneer work on Manchester University's 250-ft diameter radio-telescope at Jodrell Bank—which is still the largest fully steerable paraboloid acrial in the world—and on other smaller acrials at Jodrell Bank.

Jodrell Bank know-how went into the Post Office earth station at Goonhilly

Downs in Cornwall, South-west England, which is now being expanded to include a second big aerial.

Satellites will certainly be used to allow computer to speak with computer from one side of the world to the other, just as if they were next door to each other.

Based on tests and calculations already made, engineers have evolved schemes enabling aircraft to communicate with their base station via satellites. Many such developments can be solved technologically as soon as the commercial need is clear.

Other Projects

Although the United States and the Soviet Union have a clear lead in the design and construction of spacecraft, other countries are now becoming involved in this area of technology.

France and Federal Germany are jointly developing a communication satellite known as Symphonie; Europe may develop another tailored to the needs of the Eurovision television network; and from now on any spacecraft ordered for INTELSAT will have to be international rather than purely American.

Only this week an ambitious new satellite, 22-ft. tall and able to handle 25 times the communications capacity of the famous Early Bird, was proposed by the Hughes Aircraft Co. of California to meet the so-called INTELSAT-4 requirement for a new generation of satellites for the 1970s.

This would be built by companies in 11 countries. Hughes would be prime contractor, with the British Aircraft Corporation as the major sub-contractor and other sub-contractors in France, Federal Germany, Switzerland, Belgium, Italy, Sweden, Spain, Japan and Canada.

Communications Explosion

Satellities will not replace cables but will complement them, adding flexibility over larger areas and opening up new markets

An idea of the traffic involved is given by the capacity of the INTELSAT-4 spacecraft proposed by the Hughes Aircraft Co Just one of these satellities will be able to carry 6,000 two-way telephone calls—or 12 colour television programmes.

The experts are not exaggerating when they talk about a global communications explosions expected in the 1970s.

KENNETH OWEN

Courtesy: British Information Service

Fruit Fly Controlled By Lures

Both food and sex lures for the Queensland fruit fly, Dacus Tryoni, have been discovered and used to control the past in at least 30 inland Australian towns. The method should also assist suppression efforts along the eastern seaboard where the fly exists in a more or less continuous population from north of Cairns to Victoria.

Several State Departments of Agriculture have accepted the method as a preferable alternative to massive spraying campaigns using dangerous poison such as DDT. For almost a century the fly has been regarded as Australia's worst pest of orchard crops, but a recent conference of Federal and State entomologists declared that as a result of the im-

proved control measures now available the fruit fly problem could be viewed as one of minor importance.

Mr. A Willison, an industrial chemist in Sydney, discovered the male lure some years ago. The attractant synthesised by him is 4-(p-hydroxyphenyl) butan-2-one. Subsequently research by Dr. Monro at the Waite Agricultural Research Institute, Adelaide, showed that the acetoxy derivative of this compound was even more attractive to the Queensland fruit fly. This form of the compound also attracts the melon fly, *Dacus cucurbitae*, which is a pest in other parts of the world.

Meanwhile, American entomologists had found that certain protein hydrolysates are strongly attractive to the oriental fruit fly, melon fly and Mediterranean fruit fly Tests by the New South Wales Department of Agriculture confirmed that this material is also appreciated by the Queensland fruit fly. ICIANZ Ltd, in co-operation with the Department has since formulated a number of protein hydrolysates and selected the most effective for commercial production.

Though the sex lure has greater drawing power and is longer lasting it has not proved as effective as the food lure in field control experiments. However, when both lures have been distributed together suppression has been greatest. Thus, in an experiment covering comparable areas where male lure and food lure were used separately fruit damage amounted to 20 per cent and 7 per cent respectively, but virtually no infested fruit was found in the areas in which the two lures were distributed. Malathion has been chosen as the insecticide to mix with the lures because it presents less risk to other animals and humans.

NEW SURGERY SUCCESSFUL

A life has been saved at the Alfred Hospital, Melbourne, by means of a pig's liver. The operation in which a pig's liver was used to take over temporarily from the patient's own liver was conducted by the Department of Surgery, Monash University, Clayton, with assistance from the staff of the Alfred's dialysis unit and biochemistry section. This was the first successful performance of the operation in Australia and one of the first to be conducted anywhere. The technique was explored initially in Britain only last year.

In the case at the Alfred the patient was a young pregnant woman who had been admitted suffering from a severe liver failure. Her condition was further complicated by kidney failure and septicaemia. After prolonged labour she was delivered of a three-week premature, stillborn child The symptoms of liver failure progressed, however, and two days later she had lapsed into a deep coma. After 28 hours in this state, which normal medical procedures failed to alleviate, it was decided to connect her blood stream to a liver fleshly taken from a pig.

Shunting of blood through the pig's liver was maintained for nine hours during which the patient's condition improved. Next day she began to relapse, however. The pig liver circuit was reestablished and after a further eight hours of perfusion the patient began to recover rapidly. Soon she could talk somewhat and control her limbs, al-

though full consciousness was regained only over the course of a week. From then on improvement was continuous until the woman was able to leave hospital six weeks later She has since resumed her normal, energetic activities.

The liver used was removed aseptically from a 40-kg pig and flushed free of the pig's blood. A tube inserted in a main artery in the woman's arm was led into the vascular tree of the pig's liver. The exiting blood flowed into a reservoir from which it was pumped back into a vein in the woman's arm. The external liver adequately took over all important functions and relieved the patient's own liver of the need to extract toxic waste products, such as ammonia and bile, from the blood Although the patient's blood was passed through the pig's liver for a total of 17 hours no ill effects were detected and it would seem that the period of relief could be maintained for much longer if necessary.

HOT BODIES

The Australian National Health and Medical Research Council has drawn attention to the serious hazard presented by corpses containing radioactive substances. Mortuary and post-mortem room attendants, hospital pathologists and embalmers are at risk when a patient who has recently been given a therapeutic dose of a radio active isotope dies unexpectedly.

Because such deaths are relatively rare the risks of contamination by people handling the corpses are correspondingly high unless precautionary procedures are established as a routine in hospitals. The report sets out a code of practice for handling these corpses safely. Acceptable levels of radioactivity for each of the isotopes in common use are stated.

Hospital personnel are warned not to perform necropsies or permit embalming to be undertaken until the radioactivity has decayed to these specified levels. Instances where the main sources of radioactivity can be removed from the corpse to make it safe are outlined. For example, the corpse of a patient given gold-198 for metastatic tumour may be relieved of most of its radioactivity by withdrawing the ascetic fluid by means of a section pump. This material should then be kept under safe storage conditions for the specified time until its radioactivity has declined sufficiently Meanwhile, the corpse can be investigated or embalmed without risk.

Courtesy: Australian Information Service

Scattering of Light By Sound Waves

Density variations in liquid helium caused by the passage of sound waves have been detected by the way in which they scatter light The authors of the experiment, G. Jacucci and G Signorelli, working in Rome, say that this is first experimental evidence of this phenomenon. As such, it is a neat confirmation of some fascinating predictions about the properties of what remains the oddest of all liquids.

Helium gas liquefies at 4.21° above the absolute zero of temperature, itself some 273°C below the freezing point of water. The fact that liquid helium is converted into a solid form only by comparatively high pressures explains

why it is so widely used as a cooling material at low temperatures

At a temperature of 2.18° above absolute zero, ordinary liquid helium, however, is converted into a second form, known as helium II, which is distinguished by machanical properties which are almost bizarre. For one thing, helium II has the properties of what is called a super-fluid, which means that in some circumstances it can run up and over the walls of the vessles containing it.

The same fluid can also conduct two quite different types of sound waves, one of which resembles ordinary sound in that it consists of pressure fluctuations. The other kind, known as "second sound", is unique and consists not of a pressure fluctuation but of a temperature variation. The experiment that has now been completed is concerned with these two types of sound and the interaction between them.

One way of generating second sound waves in helium II is to feed an alternating current through a coil of wire immersed in the liquid. Even if the frequency of the alternation is as great as 10,000 cycles a second corresponding to sound with a pitch too high to be audible — the corresponding alternations of the temperature of the wire may be able to set off a temperature wave through the helium II.

Second sound can be obtained also when ordinary sound impinges on a container filled with helium II One of the most elegant generators of second sound is that developed at the Clarendon Laboratory, Oxford, in which *second sound is generated by the* rhythmic temperature fluctuations of a magnetically sensitive crystal exposed by fluctuating magnetic forces.

The experiment carried out in Rome concerns the inter-actions between the two kinds of sound. Although the hall-mark of second sound is a temperature fluctuation, it was predicted some two years ago that in some circumstances there should also be associated trains of density fluctuations in helium II, and that these should travel with the same speed as the second sound The new development consists of the observation of these density fluctuations.

In the experiment in Rome, a beam of light from an argon laser has been shone through a container of helium II in which waves of second sound have been generated at frequencies between 20,000 and 320,000 cycles a second — well above the pitch of ordinary audible sounds. The first task is to measure the fraction of the light transmitted through the helium II and the extent to which this may be scattered off the direction of the laser-beam.

The author of the experiment say the properties of helium II differ above and below a temperature of 2.1° above absolute zero. Below this temperature the laser beam is absorbed to an extent which is closely linked with the degree to which the second sound itself is absorbed in liquid helium. This is the region in which the authors suggest that they have now demonstrated density fluctuations accompanying the propagation of second sound

Between the temperature of 2.1° above absolute zero and the point at which helium II is converted into or-

dinary liquid helium, there is a more complicated interaction between the beam of laser light and the waves of second sound which may be the result which may be the results of the production of the ordinary sound waves of the production of ordinry sound, by the train of second sound.

Experiments like these should help to throw light on the complicated processes that determine mechanical properties of liquid helium. This particular experiment is an unusual demonstration of an interaction between a light wave and a sound wave.

From· *Physics letters*, vol. 26A p. 5

New Techniques for Protein Structure

Valuable information about the structure of protein molecules is being obtained by a technique known as proton magnetic resonance (PMR). Although the technique had been used with some success as a means of unravelling the structure of comparatively simple molecules, only recently it has been applied to the analysis of the structure of the much more complicated protein molecules. Simplicity is one of the most obvious attractions

So far, one of the principal ways of telling how a long protein molecule is folded up upon itself has involved the scattering of X-rays from suitable crystals of a protein. In spite of the assistance afforded by computers, however, this is a laborious technique which, in any case, applied only to proteins that form crystals.

The basis of the technique is that the hydrogen atoms in a chemical structure will oscillate at a characteristic frequency in a suitable beam of radio waves, because each of them functions as a tiny magnet The technique consists of placing a sample in a strong magnetic field and then observing the frequencies at which oscillations take place. The characteristic frequency of each proton is determined by its chemical environment These are easy to record· the problem is to interpret them in a meaningful way.

One of the most powerful PMR machines in use is at the Central Research Department of the Du Pont Company in the United States. In the current issue of the Journal of the American Chemical Society, Drs. C. C. MacDonald and W D. Phillips describe an investigation in which they have examined three proteins ribonuclease, lysozyme and cytochrome C. The structures of these have already been determined by X-ray methods.

By varying the temperature of a solution containing these molecules they have been able to record an accompanying change in the chemical environment of various protons in the protein molecule, and hence in the conformation of the molecule as a whole.

In other words, it has been possible to obtain a dynamic picture of the conformation of the molecule, as distinct from the essentially static one given by X-ray methods. The deductions made accord with the evidence gained by other means, Drs. MacDonald and Phillips have for example been able to pick out certain proton oscillations which appear in the natural protein conformation but not in that of the denatured protein.

The same measurements have also

reflected the interaction between the en zyme lysozme and the molecule that it transforms. The importance of this approach is that it opens up the possibility of examining the ways in which protein molecules in solution interact with other essential components of biochemical machinery.

This preliminary report is a striking example of the power of the big machine in biology.

How Ostriches Survive Without Water

Field studies of ostriches carried out in the Sudan have thrown up the somewhat unexpected result that these creatures rival camels in their capacity to survive without water. According to Professor J. L. Cloudsley-Thomson and El Rasid Musa Mohamed, writing from Khartum University in the current issue of nature, ostriches "can survive dehydration to a greater extent than gazelles and more closely resemble the camel in this respect"

The authors point out that because the ostrich is a large animal it can not easily obtain shelter in the desert as smaller birds do. The observations so far carried out on the ostrich struthio camelus have shown that it must have access to drinking water.

Survival is, however, made easier by the glands which it possess in the nose and which function as a means of excreting salt. These make it possible for ostriches to live off brackish or even salty water, and this is no doubt a part of the explanation of why in the Sudan, they are often found congregated around salt and soda lakes.

The experiments carried out at Khartum have been designed to see what happens when ostriches are deprived of water. Halfgrown birds were found to lose weight steadily when so deprived After nine days they would have lost about a quarter of their body-weight. By all accounts the loss of weight of about a third represents the point at which they may die.

Ostriches, like camels, are able to make good the loss of weight which they suffer on dehydration in quite dramatic ways. Birds kept without water for nine days were found to drink in one session enough water to restore all but a small fraction of their lost weight. They were able to keep alive by drinking a mixture of one-fifth sea water and four-fifths fresh water, but they seem to be unable to maintain their weight when given water that is even more salty.

Nature-Times, News Service, 1967

Blue Green Algae Help The Rice Crop

The plants and bacteria which fix nitrogen, that is, absorb this valuable element from the air and make nitrogenous compounds from it, are vital to the whole life cycle on Earth.

Nitrogenous compounds are scarce, and industry has had to supplement the efforts of the nitrogen-fixing organisms by artificial means, but the natural nitrogen fixers still remain the most important. The best known of them are the bacteria, such as *Azotobacter*, which live in nodules on the roots of leguminous plants, a partnership from which both sides benefit. But there is now a growing amount of evidence that a group of very tiny plants called the

blue-green algae also play an important part in nitrogen fixing in nature, they even be as important as the bacteria.

Blue-green algae are common on sheets of fresh water and are found forming dense masses along the margins of the sea in some temperate regions. They are also often found on the surface of wet soil, but only on the surface, since like other plants they are dependent on daylight for their growth. Their blue-green pigment traps light for energy as the chlorophyll does in green plants.

The algae are particularly common in paddy fields, and within the last few years it has been realised that they are *responsible for fixing and supplying* much of the nitrogen needed by rice plants in the form of nitrates. In this way they are vital in providing food for more than half the world's population. The next logical step is to try to improve crop production, in particular rice by adding artificially grown cultures of blue-green algae to the fields Professor Watanabe, in Japan, has carried out some pilot experiments in which large cultures of blue-green algae were added to rice crops, resulting in a definite improvement in the nitrogen content of the crop and in its overall yield. At present this is not an economic process because of the high cost of culturing the algae.

Researchers under Professor Tony Fogg of the Department of Botany at the Westfield College in North London are thinking of culturing algae on a much larger scale than has been attempted so far. One idea is to grow the algae in huge vats on large open lakes

Mr W.Stewart of Westfield College has been investigating the possible use of bluegreen algae in another agricultural role and has had encouraging results His idea is that it may be possible to use blue-green algae to colonise barren arid soils, and so help to solve the world shortage of agricultural land. Blue-green algae are natural plant pioneers. They are very often the first plants to appear on arid soils. They are able to form a gelatinous mat, which helps to stabilise loose sand grains on the surface of the soil, by gluing them together, and they immediately start to improve the nitrogen content of the soil and so make it possible for other *plants to settle, with root systems which* hold the sand together more effectively and prevent erosion. The prospects for using blue-green algae as soil coloniser in this way are good, providing the culture cost barrier can be broken.

There may be a third agricultural use for blue-green algae; that is as a source of chemical extracts to encourage seed growth. Experiments in India and at Westfield College have shown that algal extracts used to treat rice seeds make the rice grow faster and develop more. They increase the yield of the future rice plant and raise the protein content of the grain. No one is quite sure which element it is in the algal extract which is responsible. It may be nitrogenous compounds or plant hormones, or both. Other substances may be involved. But there is some natural biological relationship between algal compounds and rice growth, which, it has now been shown, can be duplicated and artifically enhanced to

improve production of the world's most important crop.

Blue-green algae are frequently the first plants to colonise arid soils. They stabilise loose sand and enrich the soil with nitrates, making it possible for other plants to get a foothold. The algae may have been one of the first organisms to colonise the land surface of the Earth, millions of years ago.

From SPECTRUM 40: Sept. 1967

'Basic Secret' of Life Unlocked

Scientists throughout the United States are discussing the implications of what is being called the artificial creation for the first time of the basic molecule of life.

The main credit for the feat goes to Dr Arthur Kornberg, aged 49, leader of the team of research workers at the Stanford medical centre, who shared a Nobel Prize for medicine with a New York scientist in 1959. He is described by his colleagues as having had "a 26 year long love affair with enzymes".

It is said that one day a student did something which caused an experiment to fail When the student confessed to Professor Kornberg that he was afraid he had let the refrigerated enzyme solution with which he was working get too warm, the professor admonished him with. "you've got to love your enzymes."

Dr. Kornberg was asked wheather he believed that he and his collegues had succeeded in creating life in the test tube. He replied: "I might be able to answer that better if you would firest care to define life. Just what do you mean by word?"

In any event, the achievement is being hailed by experts and others President Johnson told a gathering at the Smithsonian institution in Washington that it was; "An awesome accomplishment", adding "These men have unlocked a fundamental secret of life."

However Dr. Mehran Goulian, a member of Dr. Kornberg's team, said today it would be "many, many years" before any practical application would significantly help cure certain types of cancer, although "it might have some bearing on cancer."

Dr. Kornberg was born in Brooklyn and he graduated from the Abraham Lincoln High School soon after his sixteenth birthday. In those days he was known as "the smartest kid on the block."

He took his Bachelor of Science degree at City College in New York, and won a scholarship at Rochester University

Professional advancement and academic honours soon came to him. The Nobel prize which he shared with Dr. Severo Ochoa, at New York University in 1959, was for turning a mixture of inert chemicals in a test tube into deoxyribonucleic acid (DNA), but this, unlike the newly synthesized D.N.A., was biologically inactive

His friends say that "he knows what he is after, and can put things which are not of immediate importance to him.

Effect of experiment on diseases

The experiment announced by Dr. Arthur Kornberg, who with Dr. M Goulian, led the work at Standford University, is unquestionably one of the great landmarks of biology

The two biochemistry first isolated the D.N.A. molecules from virus particles which infact bacteria Each D.N.A molecule contains in a chemical code all the information to specify the manufacture of a complete virus particle. They then incubated these D.N.A molecules with an enzyme and the chemical building blocks of D.N.A.

The enzyme has a unique property of attaching to the D.N.A. molecules, and of using them as templates for the manufacture of new molecules which are identical copies of the original one. Dr. Kornberg and Dr. Goulian produced D.N.A. molecules with this enzyme and separated the newly made molecules from the original templates.

They then sent these molecules to Dr R. Sinsheimer of the California Institute of Technology at Pasadena, who infected bacteria with the synthetic molecules and showed that they could cause the manufacture of complete virus particles.

A virtually identical experiment was carried out in 1965 by Dr Sol Spiegelman at the University of Illinois, but he used a virus which has R.N.A. as its genetic material. R N A. is the other type of nucleic acid, but it acts only as the genetic material for a few viruses, D N.A is the genetic material of all cellular organisms, which is why Dr. Kornberg and Dr. Goulian's experiment is more important, and has medical significance.

How can this experiment be translated into ways of combating diseases? First, as Dr. Kornberg cautioned, the use of artificial genes in medicine is still a long way off However, if the D.N.A. of one virus can be replicated in a test tube, there is every reason to think that similar experiments can be done with D.N.A. molecules from other viruses

If the D N A of cancer viruses can be manufactured in test tubes then it should be possible to discoper fairly quickly which genes of the virus are responsible for inducing the cancer response in an infected cell.

Nature-Times, News Service, 1967

First Signs of Life

New methods for detecting the condition of the foetus in the uterus before childbirth are being used in the Department of Gynaeology and obstetrics at the Hadassah-Hebrew University Medical Centre

The death rate of mothers in childbirth, once so high, has nowadays been reduced virtually to nil But mortality of the foetus has not gone down to the same extent and the number of stillbirths has only been slightly reduced. So gynaecologists are looking for new ways of detecting the condition of the foetus, so as to take remedial action if necessary.

In some cases of Rh incompatibility, where the mother is Rh negative and the father Rh positive, the gynaecologists want to know whether the child in the womb is affected. In hadassah, Prof. W. Z. Polishuk has introduced a new method known as amniocentesis, which involves the removal of a small quantity of amniotic fluid from the womb The doctors examine the fluid in a special spectrophotometric examination This tells them to what extent the child is affected and whether they have to deliver it immediately by Cae-

sarian operation or whether they can wait for a normal delivery.

Another method being used is placentography, whereby the doctors determine whether the placent is functioning normally or not In this method isotopes are used to locate and to detect any malfunction of the placenta. In this way, the gynaecologist can determine whether there is any danger to the child in the womb, as, for instance, in the third stage of pregnancy in cases of bleeding, or whether drugs should be administered to benefit the foetus

Another technique being used at Hadassah to establish the condition of the foetus is the study of certain enzymes in the leucocytes or white blood cells It the enzymes change in quantity then the doctors know that the patient must be treated or the prognosis should be evaluated. Or the cytology of the cells ot the vaginal may be studied to evaluate placental function during the last trimester of pregnancy.

SAVING THE BABY

The number of people whose red blood cells are Rh negative varies in different countries. In China and Japan, for instance, the percentage is as low as one per cent, among the Basques, in Spain, it is as high as 35 Since Israel is a land of immigration, the percentage varies according to the country of origin of the various communities: Yementies, Persians and Kurds have a two per cent Rh negative frequency, while the percentage among the communities of European Origin reaches 15.

The Rh negative factor in a person's blood only becomes important when husband and wife show what is known as Rh incompatibility. In cases where the mother is Rh negative while the father is Rh positive, and, in addition, both his genes are Rh positive and the Rh positive factor is passed on to his off-spring in every case, a situation arises in which the mother is Rh negative and the foetus in her womb is Rh positive. The mother then produces antibodies against the red blood cells of the foetus, and these cause it to suffer from haemolytic anasmia and Jaundice. This invariably results in the death of the foetus if it is left in the uterus. In fact, the baby is doomed, unless it is removed from the womb and receives appropriate treatment by exchange transfusions. This is naturally not feasible in the fifth, sixth or seventh month of pregnancy, when the child is not yet viable.

Until four years ago, there was no solution to the problem, and all such babies were born still-born. Then a New Zealand doctor by the name of Lily performed the difficult task of giving blood transfusion of fresh Rh negative blood to the foetus while still in the mother's womb, so that it could continue to grow there until viable. In this way, the results of the blood disease were checked for a while and the

Giving these intra-uterine blood life of the foetus prolonged.
clearly on the X-Ray television screen transfusions in an extremely difficult technique, requiring great skill, modern X-Ray television equipment and teams of well-trained doctors.

The transfusion is given by means of a needle into the body cavity of the foetus and there is great danger

that the needle may damage the foetus in some way. In order to avoid this, a contrast medium injection is given into the mother's womb before the transfusion is given to the foetus. The foetus swallows the contrast medium and this causes its intestine to show up clearly on the X-Ray television screen.

To perform the transfusion X-ray television is used. This has the advantage that radiation is reduced to a minimum and the image is thrown on to a screen some distance from the operation, so that members of the team can all see the operation in process. The doctors watch the foetus on the X-ray television screen and because the foetal intestine shows up clearly, the needle may be guided so that it does not damage any other organs of the foetus. When the needle penetrates the abdominal cavity of the foetus, a polyethylene tube is passed through it, and a blood transfusion of fresh Rh negative blood belonging to the O group is given slowly over 35 to 40 minutes. The polyethylene tube and needle are then removed.

Although there is danger to the foetus in the use of this technique, it must be remembered that without it the baby is doomed to die. A decision as to just when to start giving the foetus these intrauterine transfusions is made by the doctor according to a pigment test of the fluid in the uterus which surrounds the foetus, known as amniotic fluid. This fluid is coloured yellow brown by the destruction of red cells in the foetus. According to the colour of the amniotic fluid the doctor knows the state of the haemolytic disease in the foetus. If the foetus is six or seven months old when the decision is taken that it needs these intrauterine transfusions, then these will have to be given every two weeks until the foetus is big enough to be delivered either by Caesarean operation or by induced labour.

A team of doctors in the Gynaecology Department of the Jerusalem Hadassah-Hebrew University Medical Centre has recently performed this difficult technique of giving blood transfusions to a foetus while still in the uterus, for the first time in Israel. The team consisted of Dr. H. Zukerman, who gave the blood transfusion itself, helped by Gynaecology Department doctors, Dr. A. Adoni and Dr. Y. Antebi, by Hadassah's X-Ray Department's Prof. A. Sohwartz and by Pediatrics Department doctors Dr. A. Simcha and Dr. Y. Schwil.

Dr Zukerman reports that the mother, who is of Iraqui origin, has been in Israel for 17 years. Her husband is also from Iraq. The mother has had three previous stillbirths in Israel.

She came to Hadassah Hospital when the foetus in her fourth pregnancy was six months old. According to the pigment test of the amniotic fluid, the foetus would die if a blood transfusion were not given to it within six or seven days.

The baby at that age is too small to survive a Caesarean operation. The baby girl was born last week, after having three blood transfusions while it was still in the womb, it was given three complete blood exchange transfusions within the 36 hours after birth. The baby is ten days old and is taking

its milk from a bottle already. The mother is extremely happy for she knows that but for this new technique she was doomed to be childless.

The intrauterine blood transfusion technique is being used today in America and England. However, it is regarded still as extremely difficult. Every case in the world is reported and published in literature and in only 50 per cent of cases does foetus survive.

In the last few weeks, five pregnant women with the Rh incompatibility factor have come to Hadassah for treatment by means of the new technique They know that they have now hope of delivering babies who are alive and well without the intrauterine blood transfusion technique.

Courtesy, Consulate of Israel, Bombay.

A World Oceanographic Service in the Offing

The master of a 100,000-ton tanker bound for the Persian Gulf, the skipper of a trawler on the Grand Banks, the family looking forward to a holiday on the North sea coast share a common concern: they would dearly like to know what the water will be like.

Until very recently, no one could hope to tell them. Meteorologists have been issuing daily weather forecasts for over a century, but oceanographers have had their hands full just trying to understand the sea without venturing to predict its changes.

In the past, their observations in the world's oceans were scattered and infrequent; it took months and years to work up data. Forecasting was out of the question: by the time the scientists thought he could state what would happen, it had already happened.

The bleakness has gone out of this picture over the past two decades as oceanography became a major power among the sciences. Annual world expenditures for marine research now amount to nearly $600 million with nineteen nations operating a fleet of some 500 scientific ships.

The headlong rush of technology has spread its benefits over the sea. Computers cope with data in a fraction of the time once required; unmanned buoys serve as automatic weather stations recording changes in the sea's properties; artificial satellites retransmit measurements made by buoys or make observations of their own, taking in vast areas at a single-sweep of their instruments.

Oceanographic services have made their bow. A few examples: Dutch and German freighters crossing the North Atlantic use wave forecasts to save as much as half a day off their time in transit; the U.S. Navy makes ocean temperature data available to tune fishermen and forecast the whereabouts of the Gulf Stream; the U.S.S.R. offers a complete oceanographic service to ships running on the northern route in summer between Murmansk and Vladivostok.

A further step has now been taken. A working committee of the Unesco-sponsored Intergovernmental Oceanographic Commission is planning a worldwide oceanic information and forecasting service. It already has a name and an acronym: IGOSS, the Integrated Global Ocean Station System.

Members of the committee come

from Canada, the Federal Republic of Germany, France, Japan, the Netherlands, Norway, the Ukrainian SSR, the USSR, the United Kindom and the United States. Their chairman is Dr. John P. Tully, a leading Canadian oceanographer. Also interested in the work of the committe are the United Nations Food and Agriculture Organisation, the World Meteorological Organisation and the International Telecommunication Union.

As IGOSS is now envisaged, it should meet the demands, of half a dozen categories of users. First comes shipping, directly interested in currents, waves, tides and ice conditions. Coastal warning services particularly need forecasts of storm surges, surf and tsunamis.

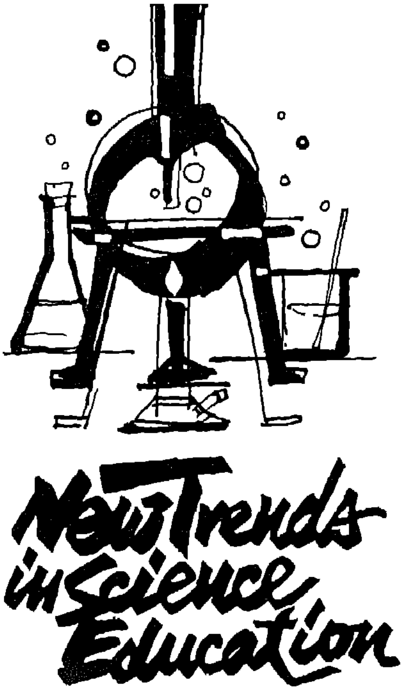
Fishermen require a broad spectrum of information on water density and temperature currents, movements of larger water masses, distribution of dissolved oxygen, the plankton upon which fish graze, and water pollution. The presence of pollution is of even greater importance to health authorities and the millions who use the sea for recreation. The latter would also like to know what to expect in the way of water temperature and surf.

Then there is science. All data from IGOSS will be available for research purposes and IGOSS itself is expected to support large research efforts. Observations will be awaited most eagerly, however, by meteorologists who need to learn the temperature of the upper layers of the ocean where future weather seems to be "stored".

To gather data, IGOSS will rely on a variety of sources: shore stations, lightships, manned platforms in the sea, ocean weather ships, automatic buoys, drifting ice islands, satellites, research ships, cooperative merchant and naval vessels, and aircraft.

A plan for the first phase of IGOSS, using these existing facilities, will be developed by the committee and presented to the 60-nation Intergovernmental-Oceanographic Commission for approval at its Paris session in October 1969. Plans for a second and more advanced phase are to be considered by the Commission in 1971-72.

The oceanographic service, IGOSS, will be developed jointly with the World Weather Watch now being planned by the World Meteorological Organisation. Oceanographers and meteorologists are working closely to get the most efficient use out of the precious radio frequencies that have been allocated to them for transmitting data.



Summer Science Institutes

AS published in an earlier issue of SCHOOL SCIENCE some 56 Summer *Institutes in Science for school teachers* were held during 1968. The Directors of these Institutes had been requested to send brief reports about their activities and representative participant account from their institutes. We publish below summaries of some reports received by us.

Mathematics

Summer Institute at Jadavpur University, Calcutta under the Directorship of Dr. D. K Sinha.

Summer Institute for mathematics teachers was held at this university from 30th May to 22nd June, 1968. Along with the American consultants there were also some British consultants at this institute. The morning sessions were devoted to lectures by the members of the staff while the afternoon sessions were devoted to film shows and quiz, group-discussions and tutorials There were discussions on *particular topics at present covered* by the syllabus and also on the curriculum material produced by the Study Group in Mathematics at Jadavpur University. These discussions were very valuable. The main courses taught at the Institute were algebra and geometry while the subsidiary courses were (i) linear programming (ii) determinants and matrices (iii) set theory (iv) statistics.

Some books of the S.M.P. groups were distributed to the participants and the Institute had a separate reference library. Every Monday was set apart for an "evaluation test". There were also some special lectures by experts.

Dr. K. C. Newbond of North Carolina University gave a talk on "Rings" while Professor B. C. Chatterji of Calcutta University talked on "Foundations of Geometry". A visit to the Computors Section to the University was organized. A special lectures on computors was given by Shri A. C. Bera of the International Computors & Tabulators Co. Ltd. The participants and the members of the staff of the Institute visited a local higher secondary school. During the period of the Institute 4 meetings of the Mathematical Association of Jadavpur were also held. The participants attended these meetings also. A meeting of the Study Group in Mathematics was also held in which along with Heads of the schools of Calcutta the participants also attended. There was a book exhibition by different publishers.

Chemistry

Summer Institute in Chemistry at Regional College of Education, Mysore, was held from April 29, 1968 to June 8, 1968 under the Directorship of Sri S. R. Rao. There were about 45 participants drawn from Training Colleges, High Schools and Higher Secondary Schools of the Southern region. The participants lived a corporate life and there was a continuous evaluation and quiz programmes. Besides the lectures and laboratory work the activities included field trips and excursions. Some of the features of the programme were:

1. Coverage of all Units and Experiments of the CHEM study.
2. Discussion of Laboratory work.
3. Film shows in-built with teaching.
4. Continuous evaluation through quiz programmes.
5. Seminars and group discussions
6. Field trips to Industrial centres
7. Post test to assess the impact of the Chemistry programme on the participants.
8. Special lectures on latest developments in Chemistry, and lastly
9. Study of the impact of the Chem Study programme on gifted children.

Biology

Summer Institute of Biology, Madras Christian College. Madras

There were 36 participants at this Institute which was held for the first time in a College and not at a University centre. The participants were in groups of 4 on some research projects with the guidance of the staff. These projects are very simple and used the least equipment. The participant felt that similar projects could be worked out in school situation and perhaps with the collaboration of some talented students. There were such 9 projects which were worked out and reports on these are being prepared for publication. This institute was directed by Dr. P. J. Sanjeeva Raj.

PARTICIPANTS' REACTIONS

Mathematics Summer Institute at Jadavpur University

This Institute provided me with an opportunity to be in the midst of a large number of mathematics teachers

from all over India and two learned consultants from U.K. All of us spent six weeks in Jadavpur University hos tel and exchanged our views about Modern Mathematics as well as some of our social experiments. Every class was full of life with good humour from the participants as well as from the members of the teaching staff. The *curriculum of Mathematics in Indian* schools is entirely out of tune and is completely inconsistent with modern developments of mathematics in other countries. I have come to know that matrices, set theory, groups etc. which are taught here in B.Sc. classes are being taught in the high school classes in London. The necessity of changing the Mathematics syllabus at school level is being increasingly felt. We were happy to learn that a Study Group in Mathematics has been functioning in Jadavpur University with Dr. D. K Sinha as Director. The participants of the Summer Institutes freely discussed the curriculum guide for Geometry prepared by the Study Group for Classes V to VII. We found the Teachers Guides a varitable mind of information to the teachers of Modern Mathematics. I had no idea of the "New Mathematics" before I came here. We have now learned after coming here facts about the "set theory" "modeller Arithmatic" "probability "victor algebra" "matrics" "play and and statistics" "linear programming" space geometry" "Transformation Translation and Reflection Geometry" etc. We were told how these could be introduced in our schools.

SUKUMAR DAS

Summer Institute in Chemistry (Mysore).

The CHEM Study approach has really been a challenging approach to many of us i.e. teachers. We have not merely fresh knowledge of the content but we have also been able to find out about nature of scientific study of Chemistry. Our lectures were all very interesting very clear to us with the help of models, charts and experiments with humorous illustrations. Film shows of CHEM study series were very enlightened. Practical work in the laboratory were very instructive. The pre-laboratory discussions as well as the post-laboratory discussions were very helpful to us. We were oriented in both contents and methods.

MARGARET DAVIES

Problems in Mathematics

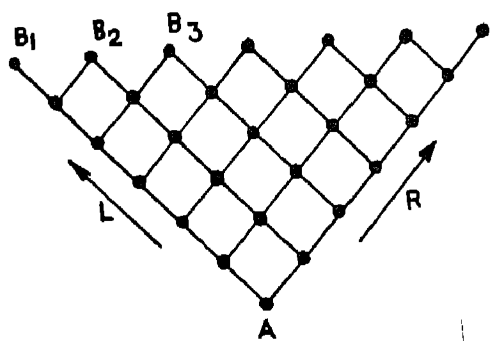
SS 46 A circle (say k^1) rolls, without slipping along the inside of a fixed circle (say k). The radius of k is twice the radius of k^1. Describe the path of a fixed point on k^1.

SS 47 Find three distinct natural numbers such that the sum of their reciprocals is a natural number. Find all possible sets of three distinct natural numbers which have this property and prove that those are the only possible sets.

SS 48 Show that the radian measure of an acute angle is less than the arithmetic mean of its sine and its tangent.

SS 49 The lengths of the sides of a right angled triangle are x metres, y metres and z metres, where x, y, z are natural numbers having no common factor. Show that x, y, z must be of the form $m^2 - n^2$, $2mn$, $m^2 + n^3$ (in some order), m and n being suitable natural numbers

SS 50 A net of roads is shown in the figure given below 2^{100} people leave the point A. Half of them go in the direction L and



half in the direction R. Having reached the first intersection, each group splits up, half going in the direction L and half in the direction R. The same thing happens at each subsequents intersection. How many people will reach each of the three leftmost intersections of the thousandth row of intersections. (The diagram shows, B_1, B_2, B_3 to be the three leftmost intersections of the sixth row of intersections.)

SS 51 Prove that the integer next greater than $(3+\sqrt{5})^n$ is divisible in 2^n, n being *any* natural number whatsoever.

SS 52 What is the greatest number of parts into which a plane can be divided by·
(a) n straight lines;
(b) n circles?

SS 53 If the integers from 1 to 222, 222 222 are written down in succession, how many 0's are written?

SS 54 Two brothers inherit a herd of cattle which they sell for as many rupees per head as there are heads of cattle. They spend all the proceeds to buy sheep at Rs. 10/- each and one lamb for less than Rs 10/- They divide the flock of sheep and one lamb so that each brother has the same number of animals. How much did the lamb cost?

SS 55 Find the smallest natural number which when divided by 21 leaves a remainder 5, when divided by 77 leaves a remainder 26, when divided by 143 leaves a remainder 4 and when divided by 221 leaves a remainder 147.

News and Notes

CASTASIA, which met in New Delhi, has focussed attention on the growing importance of science and technology in the development and prosperity of Asian countries.

CASTASIA

TECHNOLOGY FOR DEVELOPING COUNTRIES

At its closing session, the Conference on the Application of Science and Technology to the Development of Asia, convened in New Delhi by Unesco in cooperation with the United Nations Economic Commission for Asia and the Far East, has adopted a series of recommendations addressed to Asian Member States of the UN and Unesco.

The conference called on the participating governments of Asia to endeavour to reach a minimum level of total national expenditures on research and development of 1 per cent of their gross national product as soon as possible, but not later than 1980, this figure comprising current and capital expenditures financed by both governmental and private sources.

The conference further listed nine priority areas of action in Asia:

1. Full use of modern communication techniques, functional literacy programmes, science clubs and fairs, and cooperation with appropriate organizations, including women's organizations, to promote the appreciation of science with special emphasis on rural populations,

2. Improvement and expansion of science education at all levels by increasing the number and raising the qualifications of teachers with a parallel improvement of curricula, teaching materials and equipment;

3 Improvement of career prospects and possibilities of upgrading middle-level technicians, including agricultural technicians and technical school teachers;

4 Expansion and improvement of agricultural education in connection with extension work and application of multi-disciplinary agricultural research programmes, both basic and problem-oriented;

5. Strengthening and linking of existing information and documentation centres establishment of new centres and possibly regional information clearing houses, rationalization of existing systems through maximum use of

Extracts from Unesco Features and British Information Service.

modern techniques of reproduction, abstracting and data processing;

6. Development of human scientific and technological potential through improved training, employment and working conditions and equal educational opportunities for all,

7. Collaboration between universities and laboratories and creation of institutes for advanced studies to foster scientific research and technological development,

8. Formulation and implementation of *national policies integrating* education, research, technology and industry, based on the principle of endogenous development and integrated with development planning policies at the highest governmental level,

9. Promotion of international and regional cooperation through the exchange of information and scientific personnel, the pooling of resources and the transfer of appropriate technology.

On the subject of the transfer of technology, it was specifically recommended that:

1. Technology transfer and information centres be set up urgently with their functions proposed by the UN Economic and Social Council's Advisory Committee on the Application of Science and Technology to Development, and with branches wherever necessary, to provide assistance to enterprises in identifying their technological needs, the availability of external aid and in the negotiation of agreements;

2. The UN Secretary-General be invited to review the overall position of the work done in the field of the transfer of technology by different UN bodies and to draw up a comprehensive plan and programme of action for operating the transfer of technology.

3. The Conference also recommended that the Unesco Director-General be invited by the Unesco General Conference to study ways and means of establishing in Asia—under Unesco's auspices together with ECAFE and in collaboration with the appropriate international regional organization-permanent machinery to keep under regular review, stimulate and facilitate the cooperation of Member States represented at the New Delhi conference so that its recommendations can be implemented.

The scale and nature of economic development between developing countries and between the different sectors of their economies is determined by a wide range of local factors—for example, natural resources and technical skills, the relative availability and costs of capital and labour, and the size of existing or potential markets for products The choice of the appropriate technology for development has now been recognised as one of the major problems, and this is reflected in the shaping of donors' aid programmes to provide the type of equipment and technical assistance most relevant to particular cases

In some developing countries, advanced sophisticated technology is highly relevant both technically and economically in certain sectors of the economy —for example, in establishing by courtesy British Information Service large-capacity steel plants, hydro-electric power stations, and mining enterprises. Advanced processes may frequently

need to be modified to meet local conditions and limited markets, for example, a low-cost steel plant with an output calculated in thousands rather than millions of tons a year, or cement, fertiliser and petrochemical plants similarly scaled down in size.

However, in many developing countries small-scale industry is usual, particularly where agriculture predominates, and here even scaled-down versions of standard industrialised processes may be as yet inappropriate to deal with the problems arising from poor quality of output and the limitations imposed by low standards and under-employment.

The term "intermediate technology" has been used to apply to the sort of low-cost, simple, labour-intensive technology appropriate to this situation. It has been realised that, although there is a growing scope for highly sophisticated equipment in certain sectors of the economies of many developing countries, yet undue concentration upon capital-intensive industrialisation does not necessarily bring benefits to agriculture, and also provides little additional employment, while it is liable to place great strain upon the balance of payments. Moreover, it may give rise to increased migration to the towns, accentuating problems of urban unemployment, nutrition and housing. Intermediate technology is seen as a stage between sophisticated capital-intensive technology and the still prevalent primitive and inefficient methods of production, particularly in rural areas.

News & Notes

Science and Mathematics Teaching Project

From the beginning of this academic year the teaching materials for Class VI prepared in physics, biology and mathematics are being used in the 31 experimental schools of Delhi. These schools are also teaching materials prepared for this project in classes VII and VIII in all the subjects. From the beginning of this year the Directorate of Education, Delhi has adopted the books prepared under this project for all its schools starting from class VI. The Directorate of Education, Delhi is organizing a series of short duration refresher courses for their teachers of science to familiarize them with the textbooks by the NCERT and the philosophy behind the teaching of subjects as separate disciplines. The subject experts in the Department are actively assisting in planning and initiating of these refresher courses.

Three of the trial editions of the text materials for Class VIII in biology, chemistry, physics and mathematics have been completed and printed. The corresponding Teachers' Guide are being finalized for printing.

The revised edition of the materials for Class VII have been finalized and printed both in Hindi as well as in English. The Teachers' Guides for these respective texts are in print.

Additional equipment in physics for class VIII has been prepared and the equipment for class VIII is now in various stages of production

Now that all the materials for the entire middle stage in all subjects have been completed, they are being examined afresh in the light of feedback received from the teachers and others. It has been felt necessary that the syllabi have to be revised and materials prepared afresh on some of the chapters. This task has also been undertaken.

A summer course lasting for 18 days was held in the month of June and July for the science teachers of the 31 experimental schools. The participants were given lectures on the methods of teaching the new text material and they were given plenty of scope to undertake laboratory work and perform demonstration experiments for the topics they have to teach in Class VIII.

With the completion of both the preparation of curriculum materials and

the training of the teachers the Department has now begun work on the preparation of syllabus and curriculum for the next stage of the school education namely Classes IX, X and XI. As reported earlier a number of States have begun to show interest in extending this project in their States. The Education Department of Andhra Pradesh has adapted the NCERT books for their middle school Classes VI and VII They have placed some 20 schools on an experimental basis under this scheme. Other States which are showing interest are Gujarat, Kerala, and Madhya Pradesh. The schools under the Central Schools Organization are continuing to use the textbooks and materials prepared under this project.

Curriculum Project–Study Groups

The Coordinating Committee for the Study Groups met on September 9, 1968, to review the progress of the various groups. At this meeting it was decided that the convenors of the Biology and Physics groups should undertake the preparation of prototypes of kits according to the syllabus developed by them.

Physics Study Groups

The Directors of the Physics Study Groups met in Delhi and Dehra Dun to discuss the programmes for Class VIII. These groups have brought out Book I for Class V and it is now in the press. It was decided that from the different variants prepared by the Physics Study Groups the materials of Delhi and Calcutta groups should constitute the first set of reading materials for the national programme and the materials prepared by the Jaipur group should constitute the Supplementary Reading Materials.

Chemistry Study Groups

The Study Group Directors met at Vallabh Vidyanagar from 15th to 20th September, 1968. Materials prepared for the second stage of secondary schools were discussed. Four titles of books have been published during this period on the materials already prepared. These consist of one textbook for Classes VI and VII, one Teachers' Guide and two manuals one for each class.

Biology Study Groups

Early in July the Biology Study Groups had finalized materials for the middle school stage. These were printed as three textbooks and three teachers' guides. Several sets of these books have been sent to different persons to elicit their opinion and get a feedback Two titles of Supplementary Readers have been processed for printing and four more which have been received are being technically edited.

Mathematics Study Groups

There were three meetings of these groups. At these meetings Geometry syllabus for the first stage and the Arithmetic, Algebra materials also for the first stage were discussed. As a matter of strategy the study groups have decided to give first priority to the adoption of already existing materials developed by the Department of Science Education and then develop

their own materials.

National Science Talent Search Scheme

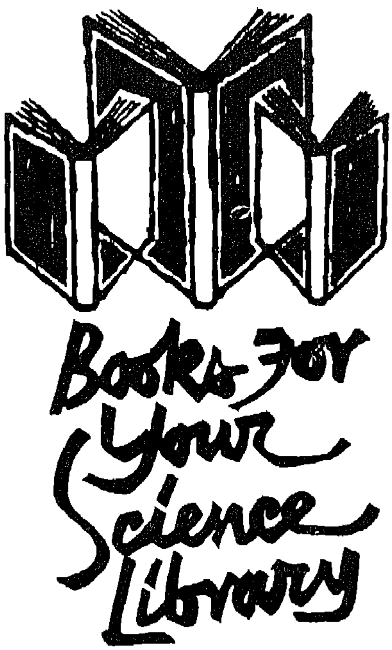
For the next aptitude test to be conducted in January 1969 it has been decided to print the question papers both in English and the regional languages. Steps have already been taken to get these translations ready and print the same.

A team of talented student from the U.S.A and the U.K. visited India and met the awardees of NSTS Scholars of Delhi at a cultural meeting. The visitors also had an opportunity of meeting Dr. D. S. Kothari.

A statistical report of NSTS Examination 1966 is under print and the Report for 1967 has been completed.

Supplementary Readers

The manuscript on "Discovery of Ocean" has been sent to the Publication Unit for printing. Another manuscript with the title "Rocks unfold the Past" is now ready for the press.



Problem Solving in Science
N. VAIDYA S Chand & Co ,
Ram Nagar, New Delhi, 1968 Rs. 12 50

Revolution in Science Teaching, about twelve years old, has necessitated thinking and action in science teaching and education at all levels in the developed as well as in the developing countries. Crash programmes for the improvement of science teaching and education are now in vogue in almost all the countries all the world over. P S.S.C , B.S C.S., Chem Study, Chemical Bond Project and Nuffield Project have become household words in the entire English speaking world both among science teachers and the research scientists All these revolutionary programmes have suffered from one chief defect, that is, the framers of these programmes have neglected the psychological structures (basis or dimension) underlying their efforts It is this neglected dimension (assumptions underlaying human thought processes with special reference to science teaching) which Shri N. Vaidya has tried to illuminate theoretically as well as experimentally in his book. In this context, this is the first book on science education to appear as there appears to be no other competing title with in my knowledge which deals specifically both in breadth and depth with science teaching from the psychological angle (See author's references as well).

The book contains seven Chapters. In the first chapter, the author describes the chief distinguishing features of the British Educational System as he saw them in operation in four different types of English Schools. Secondary Modern, Technical, Grammer and Comprehensive, in England. In his account of the History of Science Teaching in England, he refers how the English science teachers, through trial and error and over a period of 150 years, have built the English Tradition of Science Teaching whose main ingredients are reluctance to change emphasis on empiricism in contrast to too much theorizing, learning science by personal experience, development of interest and curiosity through imaginative approaches and empirical study of facts, etc like the Tale of Two Cities (and here countries), a detailed account of the position of science teaching in India follows in a lucid and enthusiastic style. The author in this account mentions the main inadequacies of school science teaching and the efforts made to improve it since inde-

pendence. This account concludes with the need for developing an Indian Tradition of Science Teaching, a job solely to be done by the workers in the field.

In the second chapter, the auothor discusses the impact of science and technology on society, nature of science and the outcomes of science education. Outcomes of Science Education have been discussed in terms of functional understanding (Vocabulary, facts, concepts), scientific skills (properly categorized), interests, attitudes and appreciations. This chapter is of importance in developing the unit as well as lesson plan objectives in the teaching learning process. Teaching is then likely to be much more broad based than is usually the case at present. At the same time, the treatment is in consonance with modern thinking in science teaching, that is 'science is an unfinished business', or to put it in the author's words. 'science defies its own definition' In the third chapter, the author discusses theoretically the nature of thinking and problem solving as viewed by philosophers and psychologists. He also mentions the logical steps in problem solving as given by Dewey in 1905 and others like Burt (1928), Gray (1935), Johnson (1944), Vinacke (1952) and Mills and Dean in 1960. On reading this chapter, it becomes apparent that the whole field of problem solving is full of problems. Interestingly enough, it applies both to the definition of problem solving and the various steps in it.

The fourth chapter is of unique importance in the book because it specifically deals with the Survey of Human Problem Solving with special reference to the Teaching of Science in the light of Some Theoretical Considerations. In my opinion, this chapter is a must to read, nay to study and to reflect over for the science teachers, college lecturers in science, practising scientists engaged in school science development programmes and researchers on thinking. On a continuum, the author discusses the educational implications from various stand points: behaviouristic (Maltzman, and Skinner's programmed learning), Gestalt psychology (in sight and productive thought), Geneva School (Jean Piaget, Barbel Inhelder), acceleration of mental development (Vygotsky & Z.P. Dienes), factor analytic and information processing. He then discusses relevant researches on concept formation and problem solving conducted both in U S.A and U.K In the remaining three chapters is described an experimental study carried on English Children in Central London, Implications for science teaching based on this study, and our problems further ahead which await invasion by science teachers and the psychologists.

The author tries hard to develop a point of view in regard to problem solving which on examination is also applicable to learning science as well. Teachers should help their students to invent and discover new knowledge. "Teaching means creating situations where structures can be discovered, it does not mean transmitting structures which may be assimilated at nothing other than verbal level." 'Children assimilate knowledge only through their thinking and action on things objects

and ideas'. They themselves have to be quite active in their learning; or to put in other words a teacher cannot give a concept (Jean Piaget).

There are however some limitations of this book For example, philosophy of science and scientific method, researches on problem solving in India (if any) and actual experimental work do not find mention in this book. Even the revolution in science teaching receives scantly treatment. These limitations, of course, do not slight the importance of this book, for the author has tacked a difficult problem. The reviewer fully agrees with the statement of Prof. Irwin Slesnick given in the foreword·

> Problem Solving in Science provides the Indian Science Teacher with a *new rationale*, for realizing process objectives in science teaching The reader is confronted with a plethora of definition and is dragged through the diffuse labyrinth of the theoretical foundations of science teaching But a comprehensive review of the research literature of educational psychology generates hope that a frame work in problem solving theory is emerging. . The day when school science is taught and learned in the manner in which science is created by man has been brought never by problem solving in science by Narender Vaidya

Ved Ratna